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Reducing Environmental Noise Impacts:

A USAREUR Noise Management Program Handbook

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This handbook provides operation and training-level personnel with practical suggestions for assessing the severity of noise problems they face and for dealing with them. The intent of this particular effort is to present noise management strategies in an "easey-to-understand" fashion. Noise management need not compromise mission or training. Actual examples of how military personnel have dealt with noise issues are used throughout this handbook. As a planning tool, this handbook addresses noise management from a general perspective through guidelines and rules-of-thumb.

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FOREWARD

Noise pollution is a major environmental problem faced by the U.S. Army in Europe. Noise-related complaints from German citizens can escalate into intense political issues in German communities. This in turn hampers efficient operation of military training and often times threatens the Army's mission.

In order to remedy these problems, USAREUR has developed a noise management program. The military mission in Europe cannot be accomplished without creating noise. However, a successful noise management program will limit the impact of unavoidable noise on the populace. This report, a component of the noise management program, is a reference document for noise management planning. It contains guidelines and rules-of-thumb for noise management. This document is not intended for acoustical engineering design -- rather it contains procedures which operation and training level personnel can understand and apply in their day to day noise management planning.

The handbook is written in easy-to-understand language. References are provided at the end of each chapter if one wishes to seek more detailed information. Noise mitigation tips are given throughout and are signified by a "light bulb" symbol in the margin. No mathematical equations are included in the text, but an appendix is provided for equations referenced in the text. References to equations are signified by a "f(x)" symbol in the margin.

Following the introductory chapter, a primer on noise is presented. This chapter provides basic technical information that will aid in understanding noise mitigation effectiveness. The third chapter presents a general framework designed to address noise problems. Chapter 4 discusses issues of noise and public affairs. Chapter 5 provides a discussion on noise management through land use planning. Chapters 6 through 9 address noise management for specific components of the military community: airfields, base operations, training areas, and housing and recreation areas. Each of these chapters describes the nature of noise generated, means of noise abatement at the source, path, and receiver (both physical and organizational/public relations methods), and a case study example.

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CHAPTER 1
INTRODUCTION

> *This handbook is ...*
> *This handbook is not ...*
> *Why worry about noise...*
> *Taking an active approach...*
> *What you will find and where...*

INTENT

Reviewing his daily calendar, local training area (LTA) coordinator Mr. Jones sees that mortar-firing drills are scheduled for today. Earlier that morning, while reading the newspaper, he noticed an article regarding the "Annual Spargel Festival" that was to take place today in the adjacent village. What should he do? Go ahead as planned? Reschedule or relocate the drill? It is a clear, breezy day. Will noise impact be alieviated or intensified? Could training rounds be used instead of high explosive rounds? Mr. Marcus, the manager of the airfield located on the other side of the village has to address similar types of questions. Should flights be rerouted or rescheduled? Will visiting aircraft be a nuisance? Can quieter aircraft be run today? How will running fully loaded aircraft affect the noise level? These are some of the considerations local training area coordinators and airfield managers have to address when faced with noise-sensitive situations. Personnel involved in other facets of military activity face similar situations. Answers to these types of noise issues are found in the chapters to follow.

This handbook provides operation and training-level personnel with practical suggestions for assessing the severity of noise problems they face and for dealing with them. Army personnel including Airfield Managers, Unit S-3s, LTA Coordinators, Major Training Area (MTA) Coordinators, Installation Coordinators, Firing Range Operators, MILCOM Environmental Planners, Motor Pool Managers, and Public Affairs Officers can refer to this handbook when addressing noise situations. This is a compilation of many other documents that address noise management. The intent of this particular effort is to present noise management strategies in an "easy-to-understand" fashion.

Noise management need not compromise mission or training. In fact, understanding noise and ways to deal with it may allow activity to occur. Mr. Jones' knowledge of the effect of wind direction on blast noise (continuing our example from above) may allow the drill to take place, where without knowing wind effects, the drill might be rescheduled. Actual examples of how military personnel have dealt with noise issues are used throughout this handbook. These examples illustrate the effectiveness of specific noise-reduction measures and provide possible solutions and approaches should similar situations be encountered.

As a planning tool, this handbook addresses noise management from a general perspective through guidelines and rules-of-thumb. Those of you who have dealt with noise issues are certainly aware that the physics of sound and noise mitigation is a technical topic. When design considerations are being made, or when research and development are being conducted, attention to these technical rules and theoretical laws must be adhered to. This handbook, though, is not a design manual. Examples of noise attenuation are given and mathematical formulas are referenced -- but only to show the range of choice you have for the noise situations you face. One should not try to design a "noise barrier wall" based upon the contents of this book. When handling significant noise problems, you are encouraged to utilize the provided references as well as to consult Army acoustical experts. Appendix A provides a list of agencies which offer such expertise.

RESPONSE TO THE NOISE SITUATION

Noise is a sensitive issue in Germany. Personal dismay and annoyance of residents are highly attributed to the incidence and magnitude of environmental noise (Federal Environmental Agency 1987). Highway noise is the most apparent problem, but military-related noise is quite significant as well. Dunning and Nolton (1988) found that noise is the most prominent environmental problem for each major category of military activity (See Figure 1-1). The incidence of noise problems range from airfield-related noise (77 percent of MILCOMs) to housing-related noise (4 percent of MILCOMS). These areas of noise problems are discussed in more detail in subsequent chapters.

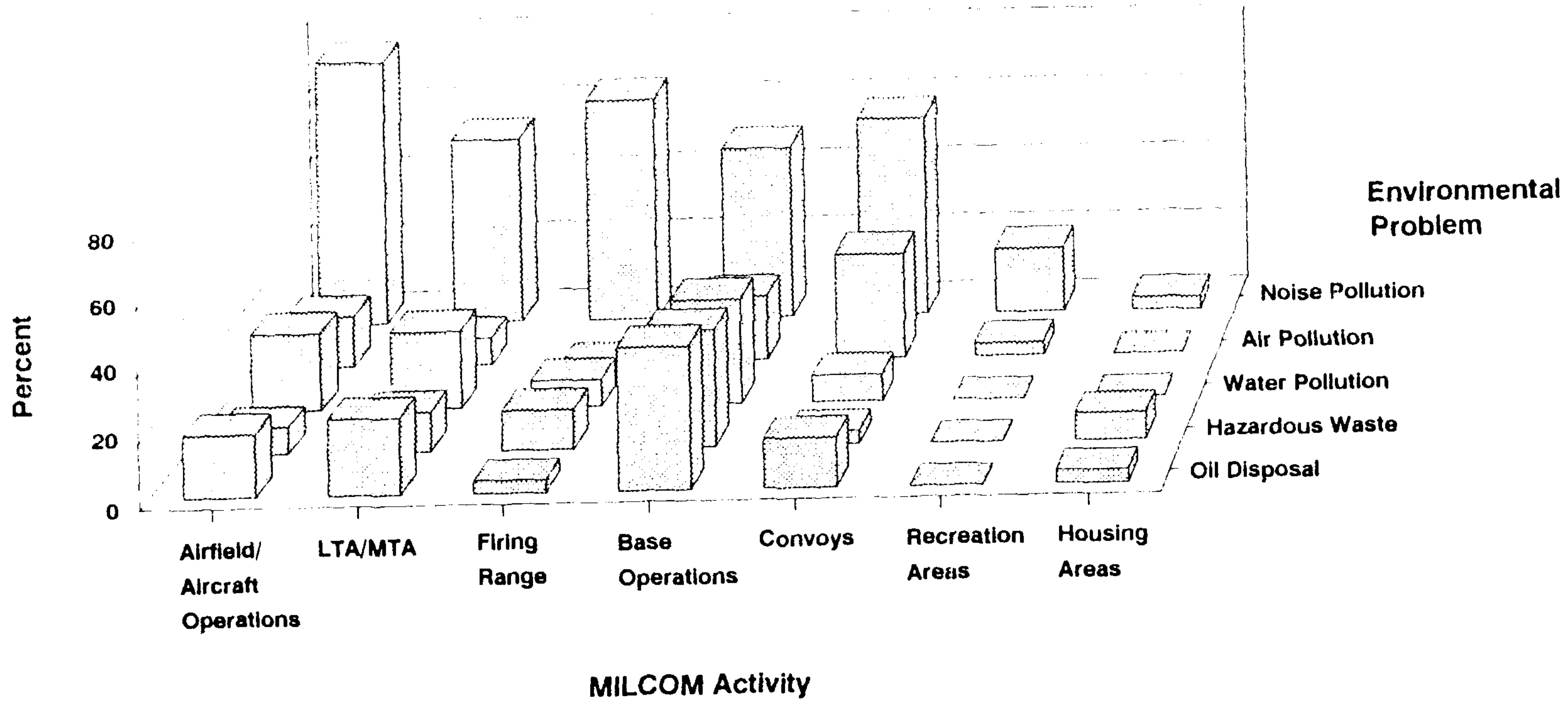

Figure 1-1. Environmental Concerns of the Army in Germany

The noise problem is rapidly becoming a risk to the U.S. Army mission in Western Europe. Response to noise requires extra manpower and hampers training efficiency. Political pressures stimulated by complaints have stunted training activities in some areas. Oftentimes, noise is used as a "whipping boy" by political groups who object to the Army's presence. A developing Germany seeks vacant land, which places pressure on military tracts. Areas used as noise buffer zones are being built up -- consequently noise problems increase. These areas of concern all contribute to increased difficulty in mission support.

Handling complaints is a very important tool in noise management, but it cannot serve as the sole approach. First, because of the complex make-up of individuals and society, complaints may be brought about by different conditions. Thus, complaints are often an imperfect indicator of the noise situation. Furthermore, how can training activities be accurately planned with a "we'll see what happens" attitude toward noise impacts? A more acceptable plan is an active approach (as opposed to a reactive approach.) An active approach to noise management seeks to identify the probability that Army activities will produce citizen annoyance. It there is a high probability that annoyance will be associated with activities, the approach suggests that steps be taken to mitigate or reduce the noise impact. The handbook assists in implementing such an active approach by providing a simple way of assessing the noise impact of Army activities and also by suggesting a number of different types of strategies for reducing noise impact. Again the key benefit of this active approach to noise management is that by anticipating noise impacts before they occur and taking appropriate steps to mitigate them, the Army will be able to reduce annoyance in terms of citizens and will thereby protect its ability to train.

HQ USAREUR's response to the noise problem in Germany is to take the active approach: to try and deductively control the noise situation. A comprehensive noise management program has been recommended (Dunning and Nolton 1988) that is designed to protect the Army's mission and improve relations with the German populace. This handbook is a tool provided under the noise management program to provide for active noise management.

HANDBOOK FORMAT

Following the introductory chapter, a primer on noise is presented. This chapter provides basic technical information that will aid in the understanding of noise-mitigation effectiveness. The third chapter presents a general overall framework designed to address noise problems. Chapter 4 discusses issues of noise and public affairs. Chapter 5 describes how noise management can be accomplished by interacting with the German land use planning process. Chapters 6 through 9 address noise management for specific components of the military community: airfields, base operations, training areas, and housing and recreation areas. Each of these chapters describes the nature of the noise generated, means of noise abatement, and a case study example.

The first five chapters contain background information aimed at general noise management. Each chapter following the fifth is concerned with a specific component of military activity and is written as an individual all-inclusive unit. Therefore, one can read the first five chapters, then skip to the chapters that are pertinent to your activity.

$\boxed{f(X)}$

This handbook is designed to be an easily accessible reference to noise problems. Special notational, summary, and format features have been made part of the book. Some of the concepts presented are based upon mathematical formulas; these will not be placed in the text but are signified by a special notation in the left margin. For reference purposes, each equation is given in Appendix B. Included in this handbook are numerous tips on reducing noise impacts. Each mitigation tip is also signified with a special notation in the left margin. References cited are given at the end of each chapter, as are references for further information.

CHAPTER SUMMARY

Military noise in Germany is a major environmental problem that is straining Army-German public relations. Consequently, increased risk to the Army's mission is being experienced. HQ

USAREUR is taking an active approach to dealing with the noise problem in Germany. This nontechnical handbook is a compilation of ideas and guidelines designed to aid the noise-planning management process.

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Dunning, C. M., and D. G. Nolton. 1988. Development of a Noise Management Program for Headquarters, U.S. Army Europe: Strawman Report. U.S. Army Corps of Engineers, Institute for Water Resources. Ft. Belvoir, VA.

Federal Environmental Agency (Germany). 1987. Environmental Data 1986/87.

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U.S. Army Corps of Engineers, Institute for Water Resources. 1988. Results of June 1988 Noise Fact-Finding Visits at USAREUR MILCOMs. Ft. Belvoir, VA.

CHAPTER 2
SOUND PRIMER

> ***Unwanted sound is noise***
> ***Sound is a wave of disturbance***
> ***Sound is measured instantly and over time***
> ***How loud is "loud" ?***
> ***Importance of understanding annoyance***

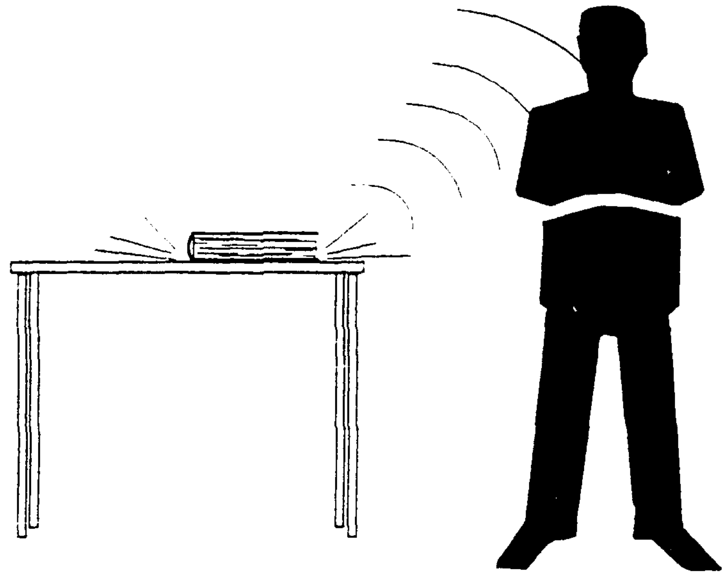
What makes sound? Maybe more importantly, what makes noise? Some things that we hear are construed as unpleasant and are unwanted sound or noise. Thus, noise is a subset of sound and both possess similar physical characteristics and are described in like terms. Measuring noise, though, requires a human perception dimension to determine "noisiness." Knowledge of the general characteristics of sound parameters is crucial to an understanding of many physical noise-abatement options. This chapter begins with an overview of sound characteristics, followed by a presentation of measurement scales. The primer concludes with a discussion of the concept of noise and annoyance.

PHYSICAL CHARACTERISTICS OF SOUND

If a book is dropped on a table you hear a "thump," as shown in Figure 2-1. The circuitry delivering the sound passes three media: the book-desk contact that causes the sound; the air in which the sound travels; and your ear where the sound is received. Remember these three media (**source, path, receiver**) - they will come up again. The actual sound created is from vibration in the air. As the wave of vibration travels from the table to your ear, it pushes adjacent air particles together and pulls some apart -- all of this causing waves of pressure change in the air.

The elements of the sound wave are illustrated in Figure 2-2. The wave of sound from the **source** (book-table contact) travels on the source **path** (through the air) to the **receiver** almost instantly -- traveling about 305 meters in one second. The number of times the wave compresses and retracts in a given unit time is defined as the frequency. Frequency in terms of the speed of sound through the air defines the length of the sound wave or wavelength.

f(X)



Sound = Source + Source Path + Detector

Figure 2-1. Noise Circuitry

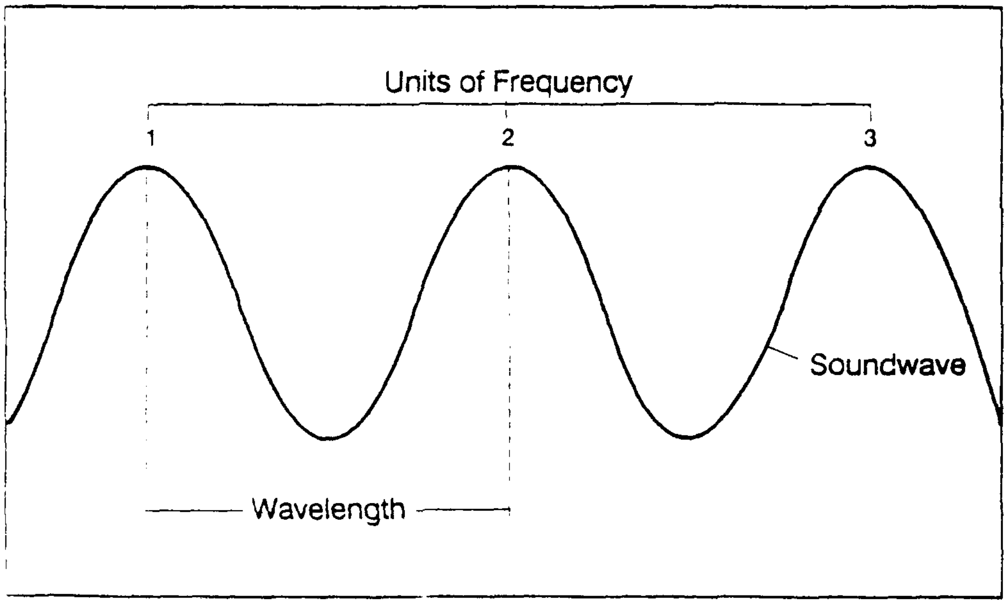


Figure 2-2. Elements of a Soundwave

The range of sound in terms of intensity and pressure can vary greatly. Approximate sound levels associated with common sounds are shown in Figure 2-3. The left side of the scale is shown in sound exposure units or pasques. Conceptually, the relation between sound measured in pasques is straightforward. Two horns blowing at 50,000 pasques produce a composite sound or 100,000 pasques. However, to bring the scale into the realm of human hearing, scientists developed a pressure ratio employing a logarithmic scale. The logarithmic pressure ratio, termed the decibel scale, numerically reduces the range of sound pressure and actually conforms to the manner in which sound is perceived by humans. Levels of sound measured in pasques and decibels are shown on in Figure 2-3.

Simple addition of decibels cannot take place because of the logarithmic nature of loudness levels. In other words, a sound of 60 decibels (dB) occurring concurrently with another sound of 50 dB does not produce a 110 dB sound. Aggregate sound levels based upon combinations of sound levels are given in Table 2-1. For example, the difference between 60 dB and 50 dB is 10 dB. The corresponding value in Table 2-1 is 0.4. Thus, the actual composite sound of these two has a sound level of 60.4 dB.

Larger Sound Level minus Smaller Sound Level	Add to Larger Level
0	3.0
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1.0
7	0.8
8	0.6
9	0.5
10	0.4
12	0.3
14	0.2
16	0.1
+16	0.0

Table 2-1. Combining Decibels (HUD 1985)

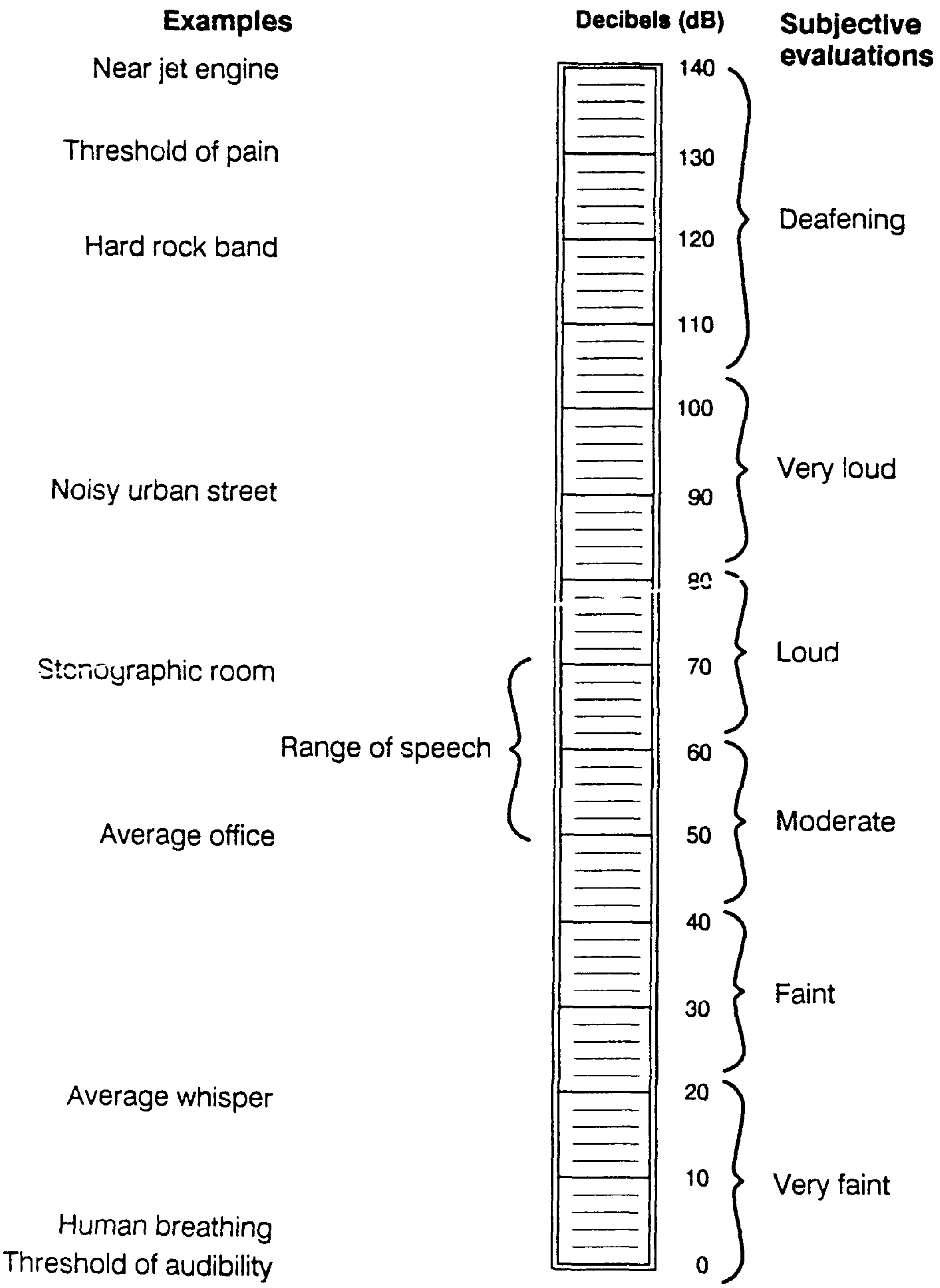


Figure 2-3. Common Sounds and Noise Levels
Sources: HUD (1985), Eldred (1989)

COMMON MEASURES OF SOUND

When studying noise regulations or technical information, one item you should note is the type of noise measurement being reported. First, consider the period of time over which the sound is being measured. Sound-level determination in its elementary form is a measure of a single (discrete) event. Sometimes, as in the case of an aircraft flyover, a noise event will occur over a defined period of time and require measurement over a specified duration. A third category of common measurements is the daily average as determined by single events measured during a 24-hour period.

The constituency or property of the sound measurement type is also very important. For example, the appropriate measure of low-frequency noise is different from high-frequency noise. The common types of noise measurement as practiced in Germany are discussed below. PMCL (1988a) and DOD (1978) provide more detailed discussions of noise measurement considerations.

Single (Discrete)-Event Sound Measurement

The two most common discrete measurements are termed A-weighted and C-weighted noise levels. The A-weighted measure is designed to closely replicate human hearing, lessening the emphasis on low-frequency noise. The A-weighting is an internationally established frequency standard (DIN 45633). The C-weighted scheme emphasizes low-frequency noise that is often accompanied by vibration. C-weighting is typically used when measuring artillary fire.

Noise Measurement with Duration

An aircraft takeoff is more than an instantaneous noise event. Consequently, measures that account for duration of the noise event are used. A noise with a constant level of 85 dB occuring for one minute is assumed equally as annoying as an 82 dB noise lasting 2 minutes. Sound exposure level (SEL) sums the loudness levels during the event. SEL measures are appropriate for A-weighted and C-weighted schemes.

Average Noise Measurements

The equivalent sound level L_{eq} is the average sound level over a specified period of time. It is calculated by taking the cummulative measure, SEL, and dividing by the period of time for which it was measured.

The rating level measure, L_r, is a special case of L_{eq}. It is a daily measure which incorporates penalties for impulse and tone and is used in German noise regulatory standards (DIN 45645 1975). Different standards are developed for day and night, with nighttime standards more responsive to annoyance penalities to account for added annoyance during sleeping hours.

The U.S. version of L_r is known as the day-night level, DNL. DNL are used in U.S. standards and are calculated as the 24-hour average noise level with 10 dB penalties for noise events occuring during sleeping hours of 2200 and 0700.

You should use caution when interpreting averaged noise measurements because harmful peaks can be "averaged out." In some situations a peak event or single measure may be a more appropriate regulatory control. In such a case, L_r may be misleading. For example, L_r may reveal an acceptable 60 dB for a noise-sensitive hospital zone. But twice a day very loud blast noise from a nearby training area causes a 90 dB event that severely disrupts patients. A situation like this would require more than just L_r to properly assess the noise situation in the hospital zone.

NOISE CONTOURS

A widely used application of noise measurement is the development of noise contours. The concept of noise contours is the same as the development of topographic maps. Point measurements are made and lines of equal noise level are developed, as shown in Figure 2-4. (Again, you should note that contours produced for "averaged daily measurements" can sometimes understate the severity of the noise condition.)

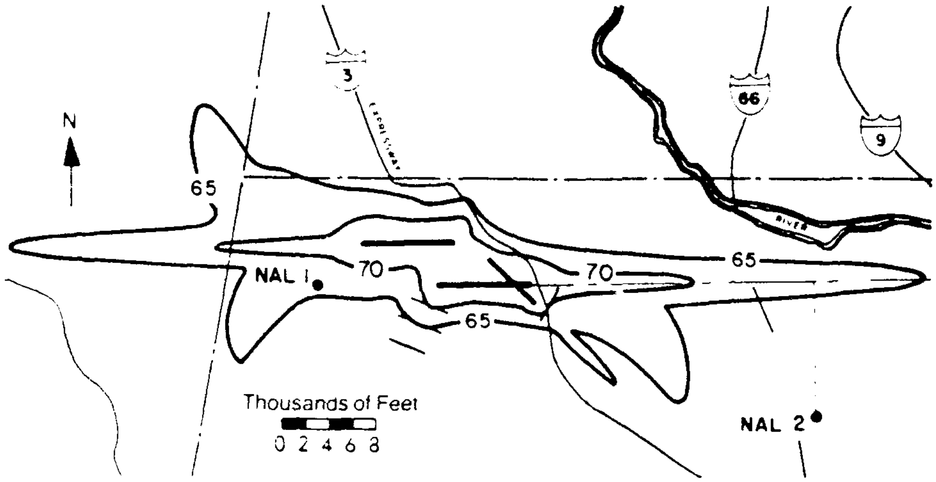


Figure 2-4. Example of Noise Contours
Source: HUD (1985)

Noise contouring is an established procedure used by all western nations. It is used for commercial airport planning as well as Department of Defense facility planning. The main benefit of establishing noise contours is for land use planning. For example, development strategies for land adjacent to an airfield should consider noise contours. Plans can be made to place noise sensitive development beyond the permissible level of noise as established using noise contours. The benefits of changes in flight paths can be quantified by deriving the net change in acreage in particular noise contours for the before and after change conditions. Information on how noise contours can be developed for your installation can be obtained by consulting acoustical experts identified in Appendix A.

SOUND RELATIONSHIPS TO REMEMBER

If a sound is emitted from a single point (see Figure 2-5), the level of loudness dissipates with distance from the point (DOD 1978). Generally, if the distance from the noise source is doubled, a 6 dB reduction in loudness occurs. If the noise originates from a

line source, such as a freeway (see Figure 2-6), doubling the distance decreases loudness 3 dB. These noise-reduction "rules of thumb" are of course dependent upon the wavelength frequency of the sound. Air temperature, temperature gradient, wind direction, relative humidity, and terrain also significantly affect noise levels (DOD 1978). A more detailed discussion regarding climatic effects is provided in later chapters.

You can estimate the sound level around you by simply talking to someone (EPA 1978). If the level of noise around you is less than about 65 dB(A), you should be able to understand someone speaking in a normal voice standing 5 feet away. A raised voice is typically required at about 75 dB(A). If the sound is 90 dB(A), you have to shout to be heard from 5 feet. The numeric range seems rather limited, but an increase of 10 dB is perceived as a doubling of sound. That is part of the "mystery" of the logrithmic scale.

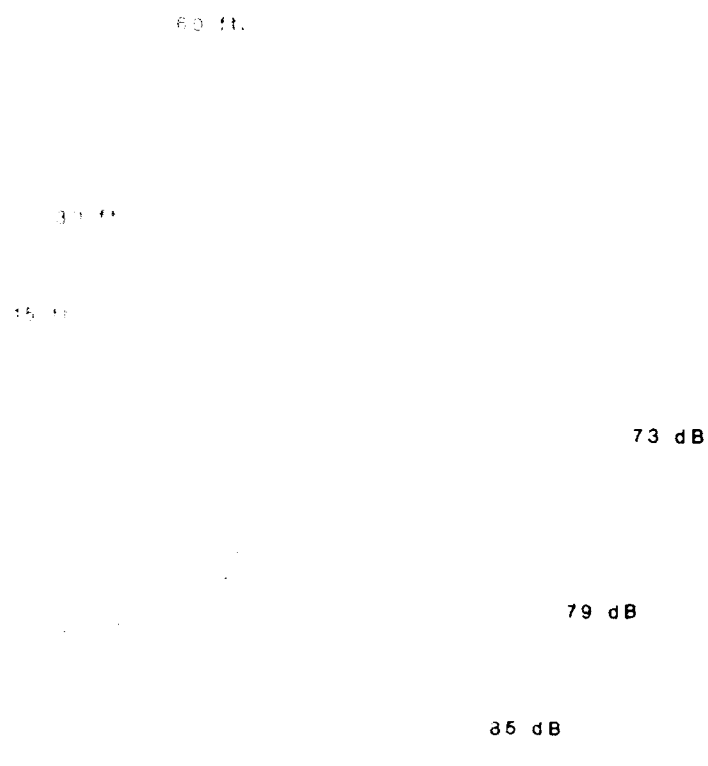


Figure 2-5. Point Source Noise Attenuation with Distance

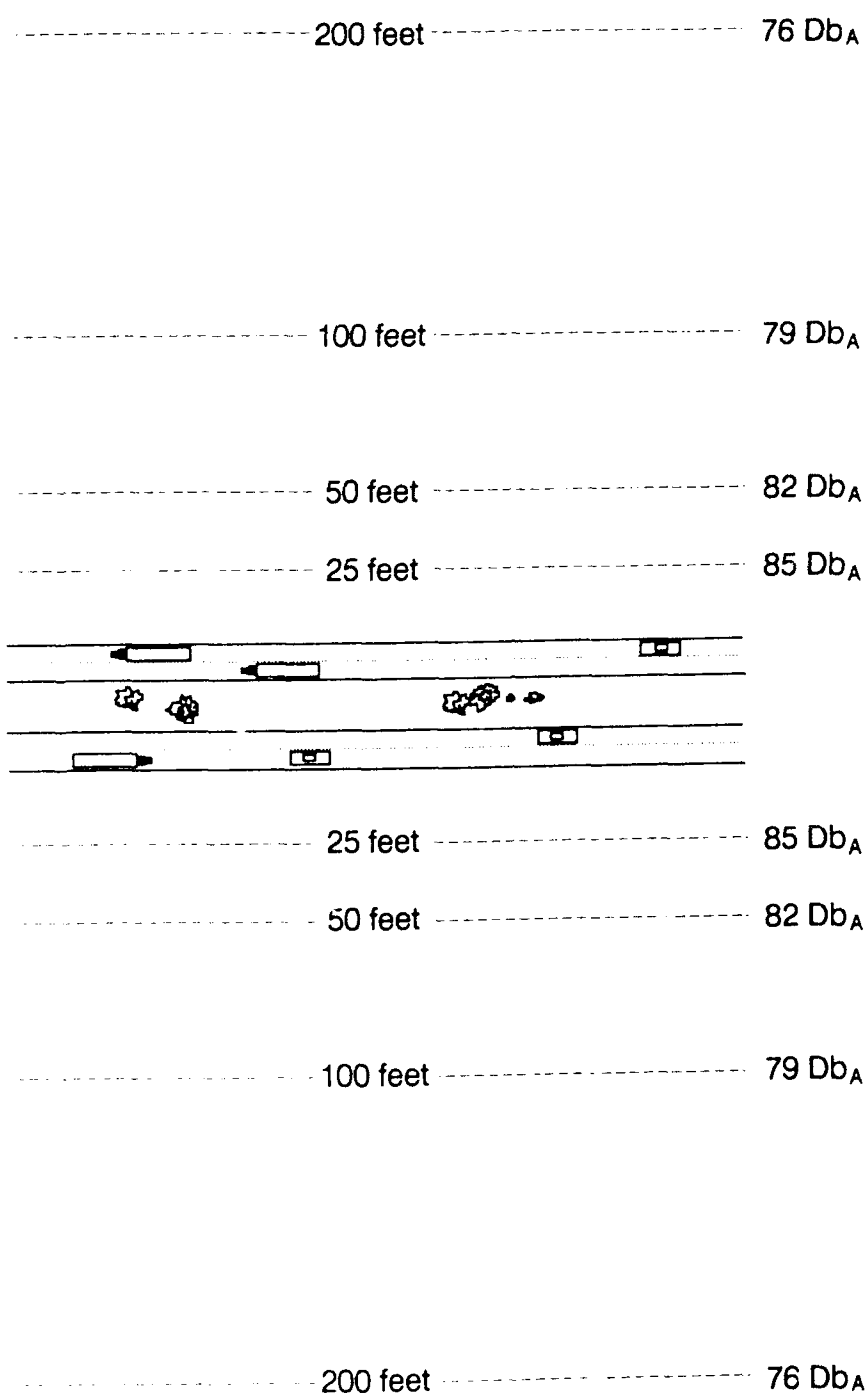


Figure 2-6. Line Source Noise Attenuation with Distance

EFFECTS OF NOISE ON HUMANS

Health Effects

Extensive noise exposure on humans has adverse physical impacts. Hearing impairment is the most prominent effect. Damage to hearing is common to those whose experience extended noise levels of 100 dB and greater. The threshold for pain occurs at 120 dB (PMCL 1988). Samuels (1981) discusses other adverse physical reactions to extensive noise exposure: increased cholesterol and blood sugar; dilation of blood vessels and pupils; stomach acid and kidney effects. Noise is also found to heighten fear, anxiety, and irritation, especially in the elderly, sick, and hypersensitive populations (Jansen 1985).

Annoyance

The concept of annoyance is very important in noise management. Until noise is considered annoying by the general populace, it does not present a problem. For example, most people don't mind hearing a helicopter as they are driving on the autobahn, but the same helicopter flying over their house at night is considered very annoying. Annoying a small group of people or even an individual deserves attention. Noise that causes annoyance is the problem and is the threat to mission activities. The point here is that determination of annoyance is as big a factor in noise management planning as is noise reduction.

Those annoyed do not always complain, but it may affect their behavior or attitude toward the noisemaker. Take, for example, an unassertive (or maybe apathetic) person who is bothered by generator noise at a nearby LTA but does not complain. How does that person react when invited to sign a petition that hampers training activity? He'll sign it! How does that person vote on a referendum to allow expansion of the LTA? In many cases he'll vote against it. These are just a couple of examples of how the political process can bring to surface the actions of annoyed persons who do not directly complain. These political pressures often translate into mission risk.

Many factors enter into the noise-annoyance situation. Human perception and attitudes toward the noise situation are quite complex and varied. Fields and Hall (1987) suggest the following general circumstances as significant in human perception of an annoying noise situations:

(1) There is a basic, underlying dissatisfaction with the existing noise situation.
(2) There is an identifiable object or authority that is recognized as being in some respect responsible for the noise or the control of noise.
(3) There is a belief that group or individual action can lead to a change in the noise situation.
(4) People must be aware of a means for contacting the appropriate authority.
(5) The introduction of a new focal point (e.g., Concorde) can substantially increase the amount of action.
(6) Social structure characteristics of an area and of society as a whole must be conducive to public action (e.g., on the community level, there is a greater likelihood of action if the community members interact with each other, and there is a commitment to the community).

Many surveys have been conducted that are used to estimate the empirical relationship between exposure to noise and annoyance. Schultz (1978) provides an assessment of such work and developed what is known as the "Schultz Curve," which relates DNL and percent of population highly annoyed (see Figure 2-7). A DNL below 50 dB annoys very few people, but as DNL increases the percent annoyed increases at an increasing rate. The relationship shown in Figure 2-7 provides a general approximation of how many people are annoyed at a given average noise level (remember the limits of daily averaging).

Given the complex nature of society's perception of the noise-annoyance relationship, empirical association (such as The Schultz Curve) should be used cautiously. The noise management theme to note from this section is that annoyance should be minimized, and controlling noises which cause annoyance is the key to effective management.

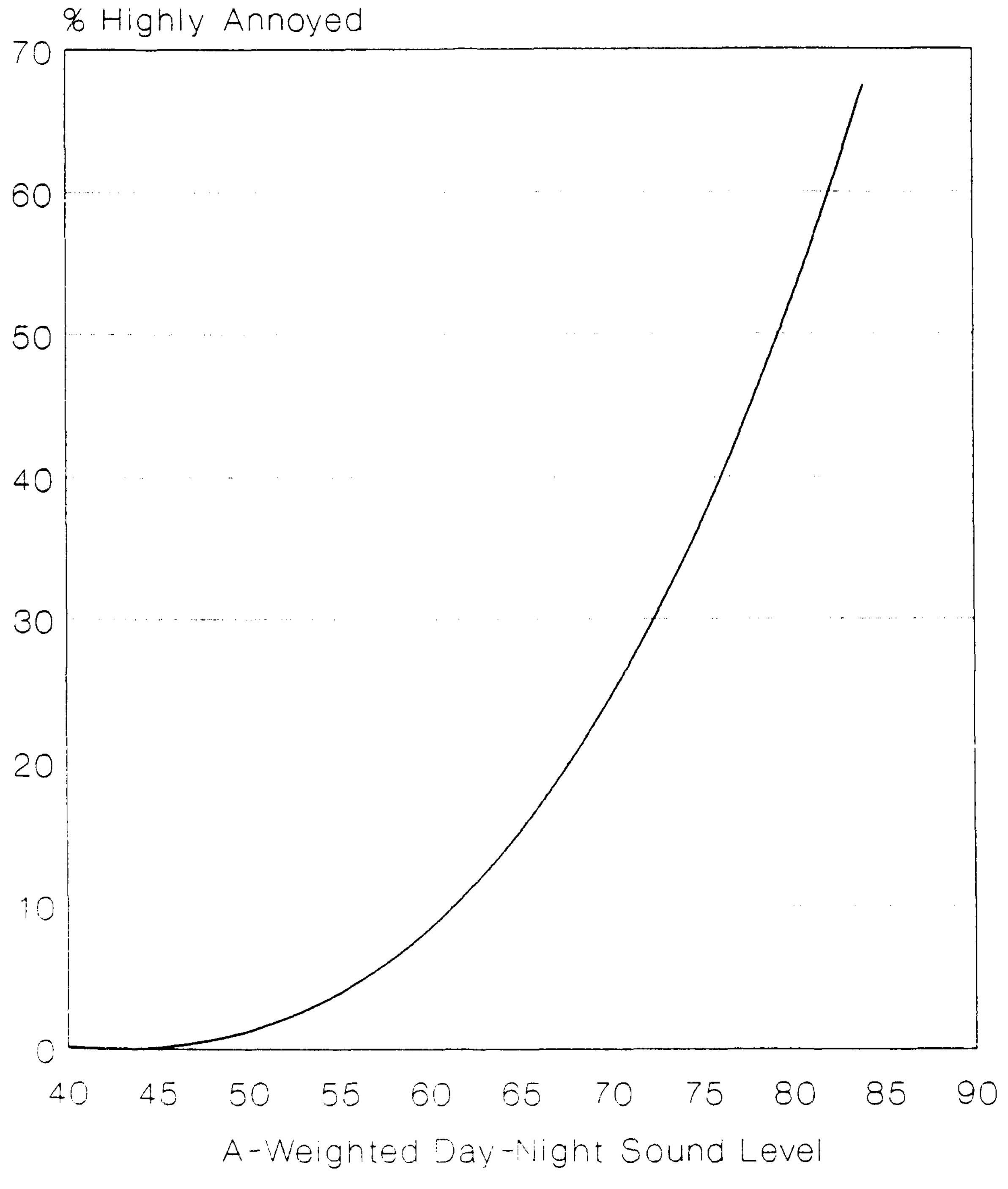


Figure 2-7. The "Schultz Curve" Relating Percent of Population Highly Annoyed to Sound Level
Source: Schultz (1978)

CHAPTER SUMMARY

You hear sound via the source, path, and receiver. It is typically measured as a single event, a short continuous event, or a daily average. If you have to raise your voice to be heard by someone 5 feet away, the sound level around you is about 75 dB. Sound level is reduced by 6 dB and 3dB with every doubling of distance for point and line sources, respectively. Sound is not a problem until it becomes annoying, therefore sensitivity toward the noise-annoyance relationship is required in noise management planning.

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CHAPTER 3
GENERAL CONSIDERATIONS IN DEALING WITH THE PROBLEM

Use common sense
Search for previous noise studies
Examine a range of abatement measures

This chapter provides a general decision-making format for managing noise-related problems. Use of "common sense" supersedes any format or framework. (Hopefully, the material presented in this handbook caters to common sense.) Many Army personnel were interviewed for the development of this handbook, and the phrase "simply use common sense" was used quite frequently when addressing noise abatement.

This framework supplements the remaining chapters in the handbook. Problem definition and provision of a range of solutions to the noise problem are the two chief concerns. The chapter on airfields, for example, provides guidelines and ideas to aid in problem definition and also presents a range of possible solutions to airfield noise problems. Similar information is provided in the remaining chapters, which cover noise management in other military activities.

This framework focuses upon noise mitigation in general; command hierarchy is not addressed. Dunning and Nolton (1988) incorporate the command structure into a noise management decision-making scheme. Aggressive noise assessment, incorporation of previous related work, and examination of a range of solutions to the problem are essential and are emphasized in the framework that is shown in Figure 3-1. The remainder of this chapter presents each component of the framework.

DOES A NOISE PROBLEM EXIST?

If you are receiving complaints, bad press, etc., then you can be fairly sure a noise problem exists at your MILCOM. As discussed in the previous chapter, complaints are not always the telltale sign of a noise problem, but they can at least be an indicator that further investigation is needed.

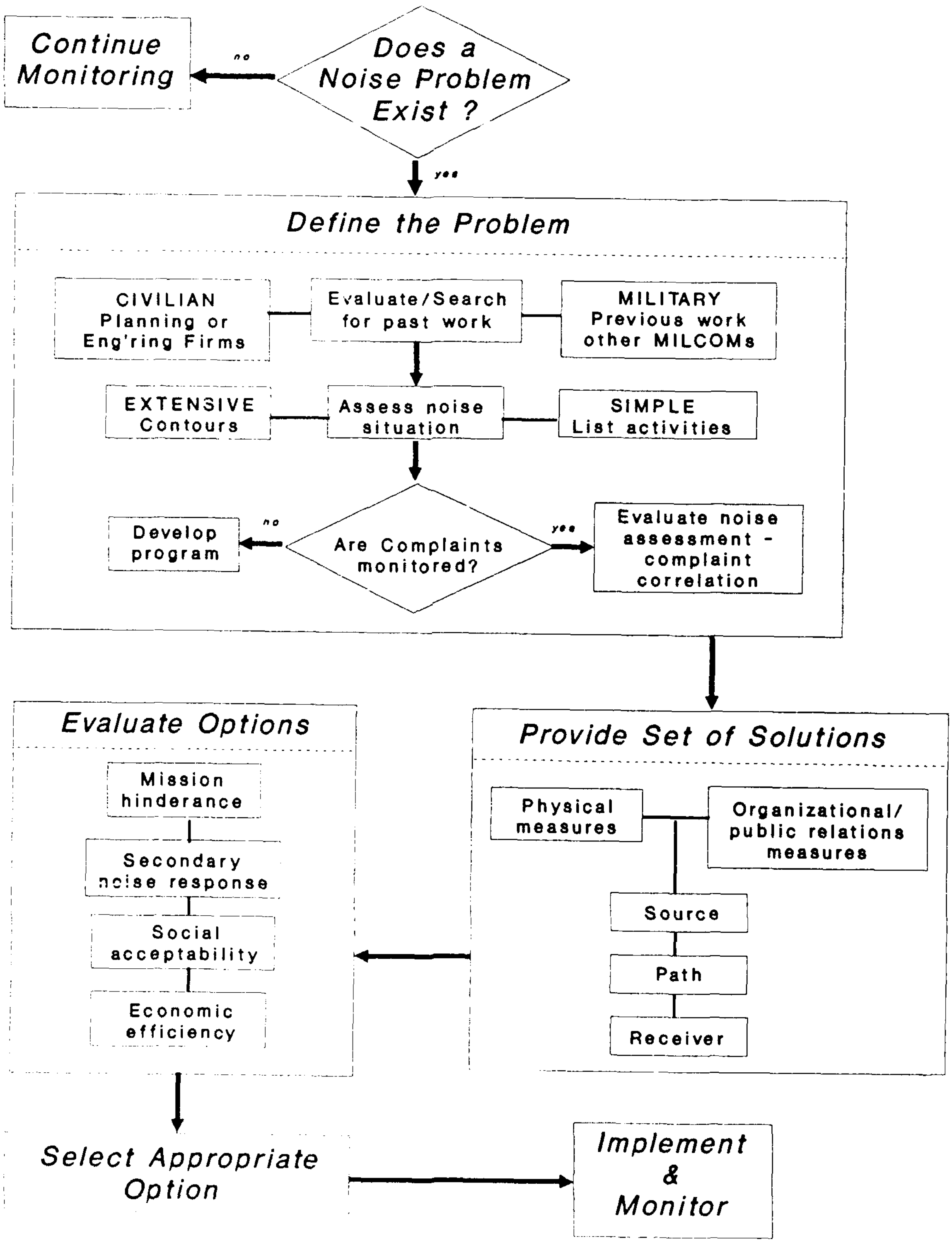

Figure 3-1. Noise Management Decision-Making Scheme

If you receive no complaints, it is still recommended that noise assessment and monitoring be conducted. Understanding the noise constituency of your MILCOM better equips you to be strategic about noise management. Forecasting a noise disturbance and abating it before it happens is "the ultimate" noise management plan.

PROBLEM DEFINITION

Proper **problem definition** is crucial to any noise management plan (as well as environmental analysis in general). An assessment should be made of the source, magnitude, and temporal patterns of noise-generating activities at the installation under investigation. In other words, try to determine who or what is making the noise, and why it is causing problems. Put yourself in the place of the Germans and ask why this activity or set of activities is annoying. This not only identifies problem areas but also places bounds on the problem. A well-defined problem is more easily resolved.

An extensive **assessment** of MILCOM noise would involve development of **noise contours**. Such contours associate noise levels to areas adjacent to the MILCOM. Should the resources not be available for contours, one can start by **listing activities** by time of day and day of the week and then denote each activity with a general indicator of loudness (e.g., not loud, loud, very loud). This will render a general daily noise trend from which peak noise events can be identified.

An assessment of the noise-making activity around the MILCOM should also take place. Remember the goal is to reveal the activities that annoy the populace. Most would agree, for example, that a run-up area produces a higher noise level than noise from a motor pool. But a run-up area situated next to an industrial park may be considered less annoying than a motor pool located in the thick of a residential area.

Environmental engineering and planning agencies, both public and private, should be contacted to disclose pertinent **past noise studies and/or measurements**. Efforts in this direction may reveal a previous study covering exactly what is needed, or at the very least, it will give you an idea of what is involved in a noise assessment. Army acoustical experts (see Appendix A) should be contacted. They are the best starting point as a source for assessing noise at your MILCOM.

Barring actual measurement, the best information on assessing noise problems can be gained from noise complaint data. If a means of fielding, recording, and responding to noise complaints is not in place, one should be established as soon as possible. What activities are causing complaints? What is the temporal and geographic pattern of the complaints? Addressing these questions through an **active complaint management** system can be a giant step toward managing noise problems. Further discussion of complaint management is provided in the following chapter.

PROVIDE A RANGE OF SOLUTIONS

When the problem is defined properly, a **set of definite solutions** can be developed. **Physical** and **organizational/public relations** noise-abatement approaches should be considered. Physical approaches stifle the sound wave at the **source**, **path**, and **receiver** (recall the discussion in Chapter 2 and Figure 2-1). Examples of physical approaches are barrier walls and gun silencers. Organizational/public relations approaches focus upon managing the problem. Meeting with citizens to hear their complaints and rescheduling noisy activities are examples of non-physical solutions that have been used in the past. These measures also can be directed at the source, path, and/or receiver.

One particular solution may stand out as obvious, but examination of a set of alternatives is encouraged. Many times the solution first reached receives a disproportionate amount of effort and is not the best solution. Efforts dedicated to examining many alternatives will at the very least help justify the seemingly obvious solution.

EVALUATE EACH SOLUTION

How is the mission altered under each potential solution? The overall objective of noise management in Germany is to protect the Army's mission. Consequently, **mission effects** are very important and must be evaluated. If one solution for airfield noise

abatement is to eliminate night flying, you have to ask if that will harm training efforts. Can simulators substitute as actual night-time flying in the training process? Could night flying be conducted in a more remote area? Sometimes compromises can be made, other times the particular alternative cannot even be considered.

Adverse acoustical reactions should be contemplated. Oftentimes a geographical shift of annoyance takes place and makes the overall noise situation worse. These **secondary reactions** occur more often than one would expect and should be taken seriously in the decision-making process. One kaserne, for example, which is completely surrounded by the city, constructed a noise barrier wall around its facility. It was effective in mitigating the noise from the facility, but it intensified the street noise. This is an example of an adverse secondary reaction to a seemingly prudent plan. Subsequently, vines that retard the sound waves bouncing off the wall were placed and are maintained on the street side of the barrier wall.

Other criteria should be established to select the most appropriate solution. These criteria will likely vary depending *upon the particular situation.* **Economical feasibility** should be considered. Is this particular alternative the most economically efficient? Is it within your operating budget? Benefit-cost type analyses should be introduced at this stage. Another consideration is **social acceptability**. A noise abatement alternative opposed by the local populace will do very little towards minimizing general annoyance and improving net quality of life. Consider reactions of each subgroup - try to determine as many societal points of view as possible. Political distortion will be introduced at this stage, but the decision maker can be certain that technical soundness and logic have been maintained to this point.

SELECT APPROPRIATE OPTION AND IMPLEMENT AND MONITOR

After careful evaluation of each abatement option, **select the most appropriate**. Ranking schemes or scoring for each criterion could be used to select the most appropriate solution. For example, the alternative with the highest benefit-cost ratio or the least cost could be selected.

When the selected program/structure is put in place, **monitoring** should be continued to ensure effectiveness. Spot checks on noise levels should be run. Complaint handling should be continued and refined when appropriate.

CHAPTER SUMMARY

This chapter has presented a decision-making framework for noise management. It supplements discussion in the remaining chapters, which cover specific noise areas. Proper problem definition and generation of a set of solutions are the key to an effective noise management plan. The decision-making framework described works best when it is employed by a noise management "team." Such a team is composed of those individuals at the MILCOM who have special knowledge of and responsibility for the different components of an effective noise management program (i.e., air fields, training areas, public affairs, DEH-MILCOM commanders, installation coordinator.) These individuals can provide mutual support, insider-knowledge which can help in dealing in a uniform fashion with the range of MILCOM Noise Management issues.

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CHAPTER 4
NOISE AND PUBLIC COMMUNICATION

> ***Communicate, communicate, communicate***
> ***Key to understanding annoyance: public affairs***
> ***Your opponent is a partner in conflict resolution***
> ***Concentrate on what is needed, not how to get it***
> ***A win-win solution is possible***

Public communication is a cornerstone of any successful noise management plan. After all, it is the public for whom the noise plan is being designed -- thus sensitivity to the public's temperament regarding noise is crucial. Recall the decision-making scheme presented in Chapter 3. Development of mitigation measures can follow two directions: physical abatement measures and public relations. Public communication is a vital concern of HQ USAREUR. In fact, a counterpart to this handbook dedicated completely to public communication and conflict management has been produced (Aggens 1991). This chapter highlights some of the points provided by Aggens and presents examples of public communication in noise management.

IMPORTANCE OF PUBLIC AFFAIRS

Justification for an active public communication program directly relates to the concept of annoyance presented in Chapter 2. Communicating with the public helps define the activities that cause noise problems. Remember, simple measurement of the sound level does not paint the complete picture. Loud sound is not the threat to mission -- annoying sound is. To attack the noise problem you need to know which activities produce annoying sounds, then possible solutions can be developed.

Military-related noises deprive citizens of privacy and quiet. The Army has a mission in Germany that requires military-related noise. These are the competing interests that cause the conflict. Unless the public understands why the noise is being produced; or conversely, unless the Army is sensitive to the public needs for quiet time, a solution to the noise problem will be very difficult to obtain. An active public communication program opens the

channels of communication between the Army and the private citizen. It allows each party to present their respective points of view. The first step toward a successful noise management program is active public affairs.

What can a dynamic public communication program provide (IWR 1988)? First, it serves as a medium for the community and MILCOM to interact. Plans for land use and development can be brought forward and discussed. Secondly, decisions made outside of court are more likely. Legal battles are very resource-intensive and can hamper efficiency of mission completion. Oftentimes, court battles fail to solve noise problems in a timely manner (a disbenefit to both parties involved). By sitting down and conferring with the community leaders and other interested parties, the Army can solve most noise disputes outside of the courtroom. This provides quicker, cheaper, and friendlier results. Lastly, the local community may find that knowledge of noise-hazardous areas would be best protected through restricted development and/or land use zoning. This action is in the Army's favor because it provides a noise buffer zone, making noise abatement much less of an issue.

HANDLING CONFLICT

How do you approach conflict or disagreement? Do you get upset or offended? Some people back down from conflict immediately. Some insist that they are right and don't stop arguing until they get their way. What comes out of a conflict is very closely related to the manner in which it was handled. Part of conflict management is controlled by individual personality, while the other part is technique. Described below are some ways of looking at problems that harness conflict for the good of both parties.

Conflict is a subset of general interaction. When you scream at the person who just stole your parking place, you are interacting, but it is also a conflict because you both think the parking place should be yours. Interaction and conflict are very much a part of the world we live in; in fact, they are an essential component of our society (IWR 1988).

When a conflict surfaces, it is important to define the actual cause of the problem. The two parties should jointly try to

understand the nature of the problem. This may seem somewhat academic at first, but it is an excellent mechanism to better define the problem (recall the benefits of a well-defined problem from Chapter 3).

To aid this definitional process, here are five common causes of conflict (IWR 1988):

Relationship	-	caused by misconceptions or stereotyping
Data	-	lack of information, misinformation, different interpretations of facts
Interests	-	incompatible interests among involved parties
Structural	-	authority or budgetary constraints and abuse, geographic distribution of resources, legal constraints
Value	-	two parties evaluate the situation based upon different criteria, diverse ideologies

Conflict is often a combination of these causes. The problem you are facing will likely fall under one or more of these headings. You and the noise-management committee should try to define the nature of the conflict. Ask questions like: Is this problem a result of stereotyping or misinformation? Are we looking at this from similar perspectives?

After the cause and/or nature of the noise problem is legitimately established, you can treat the conflict as unproductive or productive (guess which is the best approach). As stated before, conflict is simply a means of communication. An unproductive public affairs committee would have the following biases toward noise conflict (IWR 1988):

* Someone must win and someone must lose.

* We are right and we must have our way.

* Honor or personal integrity is at stake.

* The other guy is totally wrong.

A more healthy use of conflict should take the following outlook:

* No single party has a monopoly on the truth or answers.

* More than one solution probably exists.

* Sacrifices may not be necessary, a win-win solution is possible.

* The "opponent" is really a positive resource and a partner in the solution.

With these different outlooks toward conflict in mind, ask yourself again how you handle conflict? Do you look at the other party as an opponent or partner? Is satisfaction of your own interests your only objective? As an exercise think about the last conflicting situation you were involved with. Try to characterize whether "productive" or "unproductive" attitudes prevailed.

In a noise situation, the Army and the community both have specific interests that they would like to have recognized. Generally, the community wants quiet leisure time, and the Army needs to complete its mission. Respective interests get more specific for each case. For example, the community's interest may be a serene picnic area, and the Army's interest may be for a maneuvers training area. The issue surrounding the conflict is how the specified parcel of land should be used. The Army's position is that they want the land for training; the community's position is that they want it for picnicking. We have three mutually exclusive, but related, terms:

Interest	-	a party's respective need
Position	-	a party's view on how the interest should be met
Issue	-	the question or the conflict that is addressed regarding the use of the parcel of land

Sorry about these academic definitions, but they are necessary to make a very important point, which is: concentrate on interest-based solutions. Try to cater to the interests of both parties by developing a range of choices to satisfy those needs. This type of thinking was first introduced in the problem-solving chapter (Chapter 3) and is definitely worth repeating.

Position-based solutions are plagued by one-dimensional thinking, lack of compromise, and lower net satisfaction. Unless both parties feel their interests have been addressed, they have been treated fairly, and they can trust the other party, then satisfaction has not been obtained. The solution is really a "nonsolution." If the Army forces its position without regard to the community interests, then the situation is really back to square one. Complaints will continue, newspaper articles will be written, petitions will be passed around, and the Army will find itself dealing with as many problems (if not more) as before the conflict arose.

The key to interest-based conflict management is to identify the problem in terms of unfulfilled interests. The two parties should take part jointly in this exercise. Break down the major interests into "bite-sized" interests and provide a set of solutions for each. If this is carried out for each "bite" of interest, a number of solutions can be obtained. Each package should be evaluated in terms of feasibility, secondary reaction, etc., as described in Chapter 3. Once again, the companion handbook on complaint management (Aggens 1991) presents additional details on interest-based conflict management.

TECHNIQUES IN PUBLIC AFFAIRS

Complaint Management

In a "best case" situation, potential noise problems should be identified before the fact and mitigated before complaints arise. The reality is the opposite, complaints usually stimulate noise mitigation. Consequently, complaint management is an important part of public affairs programs.

The most important step is to make sure you have a complaint- handling system in place. If the noise problems caused by your MILCOM are made apparent to you through the newspaper or some other third party, then something is not right! The local community needs to be allowed to vent its frustration. They should know who and where to call or write if they are annoyed by noise from your MILCOM. Advertise the "complaint center" in the newspaper and at civic meetings and make sure local officials know where to direct such complaints. High

visibility of the "complaint center" sends a positive message that the Army is truly concerned about the community's needs.

Coordination of complaint management requires communication among Army officials. The following four steps are recommended for handling noise complaints (U.S. Army Training and Doctrine Command, 1982):

(1) Complaints are received by the Public Affairs Officer (PAO), who is responsible for ensuring the complainant is aware of the installation's mission and that every effort will be made to correct the problem, mission permitting.

(2) The PAO routes the complaint to the office having responsibility for the type of activity that created the noise complaint. The PAO requires a response for the purpose of providing information to the complainant.

(3) A copy of the complaint is furnished by the PAO to the Directorate of Engineering and Housing (DEH). The DEH has overall responsibility for the environmental program and can provide technical assistance to both the PAO and the noisemaking activity.

(4) The noisemaking activity completes a follow-up by identifying the cause of the noise and any actions taken to correct the problem. If action is inappropriate, then this will be documented. A copy of the follow-up is provided to both the PAO and the DEH.

Two additional points need to be made here. First, legitimate follow-up to the complaint goes a long way in public relations terms. The complainant is made to feel legitimate and important. Secondly, keep the complaints on record. Trends of the location and source of complaints are invaluable for technical mitigation.

Keeping the Public Up-to-Date

A very successful public relations tool used in handling noise problems is making sure the public knows why the noise is being made. If noise-making activity is necessary, most rational citizens would be more tolerant of these activities. Bob Cole (1988) of the U.S. Army's Fly Neighborly Program maintains:

> success is based on telling people exactly what is going on; giving them information.

Some noise is an actual oversight or is caused by Army mismanagement. Again, if the public is informed of this and is told that the Army will make every effort not to let it happen again, this will likely be appreciated and accepted by most of the community.

The impact of one-time noise activities can be lessened if the public is forewarned. Take, for example, a large-scale training exercise that takes place once a year. Announcements of the exercise made through the newspaper, television news, etc., will allow the public to prepare. Anything that can be done to prevent noise from sneaking up or startling the public benefits the situation.

Activities such as open houses or booths at festivals show a more human side of the Army to the public. A colonel dressed in blue jeans, talking to individuals in a social situation is good public relations. So, be sure to mix business with pleasure -- show that you are concerned for the community, but do it in a casual and easy going manner.

Many times the noise being created at the MILCOM is no louder than noise from the street. Thus, publication of the empirical fact will be useful. If measurement devices are in place, a daily noise index could be developed similar to wind-chill, heat, and pollution indexes provided in many U.S. newspapers. The Army could use this in its defense as well, stating, for example, it exceeded normal noise levels 10 percent of the time in the last year. A major drawback would be if normal noise levels were shown to be exceeded 90 percent of the time! (Then again, problem definition is the first step to a solution.)

Community Meetings

Formal public meetings can also be used to open communication with the public. The needs and constraints of the parties involved are made known and solutions are derived by input from both sides. Participants develop a proprietary interest in the outcome (Dunning and Nolton 1988).

Many MILCOMs in Germany have developed Community Relations Advisory Councils (CRAC) or something similar. This is an excellent first step toward understanding the community and is highly recommended. Noise issues are discussed often at CRAC meetings and many Army-community resolutions have come about. Oftentimes, expertise of technical personnel from both the Army and the community are solicited and are made part of CRAC decisions.

An operational note on forming meetings. The PAO or person in charge should determine what type meeting would be best for the situation. Should it be open or closed? Will the material discussed be of interest to everyone in an open meeting? Would efficiency be fostered with a small group? The nature of the issue, the number of potentially affected communities and citizens, the relationship between the Army and other parties, and financial resources must be considered in the planning process (PMCL 1988). These types of questions are covered quite well in the ICUZ Community Involvement Manual (Creighton).

CHAPTER SUMMARY

An active public communication program is vital to managing noise problems. It provides the communication necessary to define activity that causes annoyance. Both parties involved in the dispute must work together to solve the problem. Concentrate on interest-based, rather than position-based, problem solving. The public affairs office should develop complaint management, public information, and public-meeting planning skills.

Developed by the U.S. Air Force, the Flug Kontrolle (FK), or flight monitoring program, is a coordinated attempt by the U.S. Forces and local German communities to reduce the number of noise-related complaints received from the German public. It specifically addresses those complaints which stem from noise made by U.S. aircraft. The FK program has been instituted as a local initiative at both the Spangdahlem and Sembach Air Bases. The program contains actual demonstration flights which allow the German public to learn how aircraft sound at different height intervals. The FK program also provides an outlet for the local people to discuss their complaints with actual U.S. flight officers.

Developing an effective local Flug Kontrolle program requires a concerted effort from both American and German representatives. It is necessary for American military officials, preferably from the local air base, to meet with the local German officials and discuss the FK concept with them. The purpose of such a discussion would be to explain the program and its objectives, field questions from the officials, obtain their input on program implementation, and receive approval of the final conditions of the FK program for their respective communities.

In the initial phase of the program a fly-over by U.S. aircraft takes place at specified altitudes. This enables the public to experience noise levels while knowing the actual fly-over altitudes. This process is usually very enlightening for the public participants. For example, at the Spangdahlem Air Base the townspeople had been complaining about fly-overs of allegedly 300 feet. Fly-overs were carried out at full power at 500 feet. This convinced many of the townspeople that the aircraft were typically flying much higher than 300 feet. It also gave the people a more accurate framework with which to understand aircraft noise.

The second phase of the FK program takes place on the ground. Its purpose is to quickly address any local noise complaints that might occur during active aircraft maneuvers. This part of the program is performed by one or more German-speaking American pilots who use a vehicle to patrol those areas that normally produce aircraft noise complaints. It is very important that the German public recognize the FK pilot(s). Dressed in his flight suit, the pilot patrols the area in a vehicle clearly marked "Flug Kontrolle." The pilot drives the FK vehicle slowly through the area while normal aircraft operations are

underway; this allows citizens the opportunity to talk to the pilot about aircraft operations and the concerns they may have with them. When patrolling, the officer should make stops at various local gathering spots to give people a chance for personal contact.

The job of an FK officer requires an aviator who has considerable local experience, rather than one who is new and is unfamiliar with the local communities. This officer should possess extensive knowledge of local aircraft operations, as well as of local geography, terrain, and communities. The FK officer should also be a "people person" who can communicate effectively with the German public.

The Air Force has found that the number of formal noise complaints are significantly reduced where the program has been implemented. The program seems to reduce formal complaints in several ways. First, the actual planned fly-overs provide citizens the opportunity to see aircraft at different heights, which enables them to witness first hand what is considered legal and illegal flight activity. Secondly, by having U.S. representatives in the local area, some citizen concerns can be addressed on the spot. Thirdly, the FK pilot can explain aircraft operations to interested/ concerned citizens, and can increase understanding of procedures. Lastly, the mere appearance of the FK truck "patrolling" the area serves to reassure the civilian populace that the Air Force is policing its own operations, and that its aircraft are therefore likely to be following correct procedures.

Lessons learned from the Flug Kontrolle Program are:

<u>Do</u>

* Use technical experts as FK officers (supplemented as appropriate with German translator).
* Use "people person" as the FK officer.
* Conduct FK operations when actual aircraft operations are underway.
* Conduct FK operations in areas where aircraft noise complaints have been received.
* Use personnel who are experienced with the local aircraft operations, and the local geography, terrain, and communities as FK officers. It is not a job for a newly arrived aviator who does not know the local communities.

Do Not

* Permit FK officer to engage in political discussions or to give his own opinions about political issues - stick to the technical details of aircraft operations.
* Let Public Affairs Officers get involved in day-to-day operations. The FK program should look to citizens like an official patrolling by the U.S. of its aircraft operations rather than as a public relations tool.

ILLUSTRATIVE EXAMPLE: SPINELLI BARRACKS OPEN HOUSE

Spinelli Barracks is located in the midst of Mannheim. It is a transportation hub that houses maintenance and storage facilities. Most of the noise complaints come from residential areas adjacent to the barracks. The main sources of complaints are noise from the maintenance facility and noise and traffic from transportation equipment.

A woman who lives with her husband in a house adjacent to the maintenance facility submits the following complaint:

> For several weeks work has been ongoing throughout the night at these maintenance halls; soldiers, however, do not work on the engines inside the hall, but park them outside and let them run for hours.

Other complaints surround the high traffic especially during the REFORGER (Return of Forces to Germany) exercises that are held annually. REFORGER is an activity under NATO and requires the use of equipment stored at Spinelli Barracks.

To inform the public of activities happening at Spinelli Barracks, the PAO organized the Spinelli Barracks Open House. Refreshments were provided and the U.S. Army Band entertained. Trucks and other equipment were displayed so participants could get a close look at them. One of the main messages that came across was the high degree of skill required to operate and maintain the equipment. Participants were encouraged to sit at

the wheel of some of the big trucks to get a feel for the driver's perspective. The concept of safety and well-maintained machinery was made evident.

A copy of the program issued to each of the participants is shown in Figure 4-1. A map of the buildings and equipment setup are provided, as is the history of Spinelli Barracks.

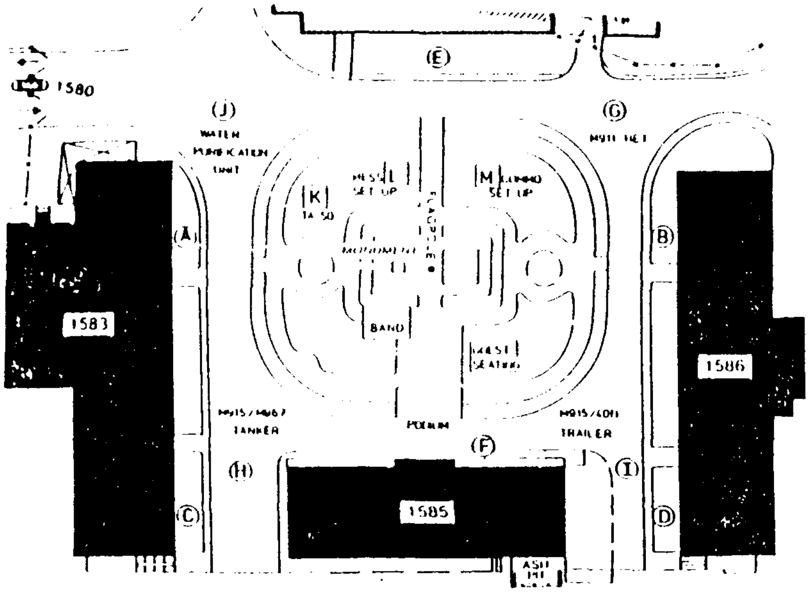
The open house was well received. Information was gained by both the citizens and the Army. The following article appeared in the *Mannheimer Wochenblatt* to cover the event (translated):

OPEN HOUSE DAY IN FEUDENHEIM

CURIOUS BUNCH OF VISITORS BEHIND BARRACKS WALLS
Transportation Units in Spinelli Are Proud of Driving Without Accidents/Participated in Berlin Air Lift

"It's fun to be friendly," was the motto with which the 28th Transportation Battalion welcomed residents living in Kaefertal, Wallstadt, and Feudenheim. The Americans opened the barracks doors to overcome the shyness of the residents and to improve the relationship with them. The close neighborhood of the military installation to Feudenheim and the recurring traffic problems of the transportation unit in the "Aubuckel" area were the reasons to open the gates for the public. Even though Saint Peter opened up his gates as well and sent down lots of rain, the "good-will-day" did not suffer from it. The official part of the ceremony was held in the Spinelli gym where the U.S. Army Band provided musical entertainment.

After the flag parade and the national anthems, the Installation Commander of the 28th Trans Bn, LTC David M. Lyon, welcomed his guests. City Councillor Alfred Rapp, representing the City of Mannheim, thanked the Americans for their invitation to that first "neighborhood day."



A, B, C, D*	TRUPPENUNTERKUNFT TROOP BILLETS
E	TURNHALLE GYMNASIUM
F	HAUPTQUARTIER HEADQUARTERS
G*, H*, I*	FAHRZEUGE VEHICLES
J*	WASSER AUF BEREITUNGS ANLAGE WATER PURIFICATION SYSTEM
K*	AUSRUESTUNG DES SOLDATEN INDIVIDUAL EQUIPMENT LAYOUT
L*	FELDKUECHE FIELD KITCHEN
M*	FUNKERZELT COMMUNICATIONS TENT

SPINELLI BARRACKS

OPEN HOUSE

16 JULY 1988

Die Geschichte der Spinelli Barracks

Die erste Einheit, die ihren Sitz in den Spinelli Barracks hatte, war ein deutsches Pionierbataillon. Damals hiess sie jedoch "Rheinhard Kaserne", benannt nach General Rheinhard, dem wohl beruehmtesten Pionier waehrend des Ersten Weltkriegs. Die Soldaten des Pionierbataillons bauten Pontonbruecken und waren auch fuer Abriss zustaendig, der sowohl mit motorbetriebenem Geraet, aber auch noch mit Hilfe von Pferden durchgefuehrt wurde.

Die U.S. Armee uebernahm die Rheinhard-Kaserne im Jahre 1945. Die bis dahin bestehenden Anlagen wurden betraechtlich erweitert. So wurde mit dem sofortigen Bau von ungefaehr 300 Buerogebaeuden und Lagerhallen begonnen. 1946 wurden die Spinelli Barracks zu einem riesigen Depot fuer die 7. US Armee und kam dann in den Zustaendigkeitsbereich der 1. Unterstuetzungsbrigade (Support Brigade). Im Spaetjahr 1946 wurde das Depot nach Germersheim verlegt; somit verlor die Kaserne ihre Depot-Funktion.

In den Jahren 1960 bis 1965 wurden viele Lagerhallen abgerissen, da sie stark verwittert waren. Das nun gewonnene Land wurde zum Stellplatz fuer Fahrzeuge, die waehrend der jaehrlich stattfindenden REFORGER-Uebung eingesetzt werden (REFORGER= Return of Forces to Germany = Rueckkehr von Truppen nach Deutschland). 1969 wurde mit dem Bau des ersten von 12 Lagern begonnen, die unter der direkten Verwaltung der NATO stehen. Das Gesamtprojekt wurde 1971 abgeschlossen.

Das 28. US Transportbataillon uebersiedelte im Jahre 1973 von den Turley Barracks in die Spinelli Barracks. Waehrend des selben Jahres wurden die Zivilen Versorgungsgruppen 4094 und 6970 in der Kaserne aktiviert. Eine weitere Einheit, die 574th Supply and Service Company (Nachschub und Wartung), wurde im Jahre 1987 von den Taylor Barracks in die Spinelli Barracks verlegt.

Die Kaserne erhielt ihren jetzigen Namen im Jahre 1945, zu Ehren von Private First Class Dominic V. Spinelli. Der Soldat wurde am 14. April 1945 in der Naehe von Wilsbach bei dem Versuch getoetet, waehrend starkem Beschuss verletzte Kameraden zu retten. Fuer seinen heroischen Einsatz wurde Private Spinelli posthum der "Silver Star" verliehen. Private Dominic V. Spinelli diente bei der 398. U.S. Infanterie.

The first unit to occupy Spinelli Barracks was a German Combat Engineer Battalion. At that time, the installation was called "Rheinhard Kaserne," named in honor of General Rheinhard, the famous engineer general of World War I. The German units built bridges and performed demolition using partly motorized and partly horse drawn equipment.

The United States Army requisitioned and expanded Rheinhard Kaserne in 1945. Immediately work began to build three hundred office buildings and warehouses. In 1946, this installation became a big warehouse depot, commanded first by 7th Army, and then by 1ST Support Brigade. Later in 1946, the depot was moved to Bermersheim and the installation lost its depot function.

During the period of 1960-1965, many of the buildings were dismantled due to weathering. The land was then used for storage of vehicles for Return of Forces to Germany or REFORGER. In 1969, the first of twelve Humidity Control tank storage buildings commenced. The project, under the control of the North Atlantic Treaty Organization or NATO, was completed in 1971.

The 28th Transportation Battalion moved to this installation from Coleman Barracks in 1973. The 4094th and 6970th Civil Labor Groups were established on the Kaserne during the same year. The 574th Supply and Service Company moved to the installation in 1987, from Coleman Barracks.

The installation was renamed in honor of PFC Dominic V. Spinelli in 1945. PFC Spinelli was killed in action on April 14, 1945, near Wilsbach, Germany, while serving with the 398th Infantry. His attempt to save his wounded comrades while under heavy enemy fire. His gallant action earned him the Silver Star medal posthumously.

He reminded the audience that soldiers of the 28th Trans Bn had helped to establish the Berlin Air Lift 40 years ago. The peaceful response of the West toward an act of violence from the East is even today a reason to be proud.

On behalf of the 33rd Pioneer Battalion of the German "Wehrmacht," Hans Dlugosch mentioned the pioneers' move from the Kaiser-Wilhelm Kaserne (Turley Barracks) to Feudenheim 50 years ago. Former enemies have become friends, the veteran stated.

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CHAPTER 5
NOISE MANAGEMENT THROUGH LAND USE PLANNING

Land use planning could prevent many noise problems ***U.S. involvement in German planning process is critical*** ***Bureaucratic "red tape" needs to be lessened***

Public opposition created as a result of noise-related annoyance can impinge on the Army's ability to train. The Army can reduce this threat by preventing new residential and other noise sensitive development from being built in areas impacted by Army noise. In the United States, the Army, Air Force and Navy, have instituted Installation Compatible Use Zone (ICUZ) programs which work with civilian land use control agencies to prevent noise sensitive development from occurring in noise impacted areas. While the particulars of how ICUZ programs are applied in the United States may not be pertinent in Germany, the central concepts do apply. This chapter presents ideas on how MILCOMs can reduce noise conflict by influencing the development of land uses adjacent to MILCOM assets.

The purpose of this chapter is not to provide an exhaustive description of the complex system of German land use planning, but rather to provide a framework to show how and where the Army can be most effective in achieving its objectives. In particular, the focus of this chapter is on preventing the spread of noise-sensitive development into areas that are impacted by Army noise.

LAND USE PLANNING IN GERMANY

The Legal Framework

Germany's federal government, referred to as the Federation, operates under constitutional guidelines outlined in the Basic Law, or *Grundgesetz*. As defined in the Basic Law, the

16 states in Germany operate as individual political units, with each having its own constitution and parliament. According to Article 75, No. 4, of the Basic Law, the German federal government has the right to enact framework legislation concerning land distribution, regional planning, etc. This constitutional provision has provided the basis for legislation such as the *Bundesraumordnungsgesetz* (Regional Planning Act of 1965).

Generally, the Federation deals with tasks related to nationwide legislation and foreign policy, while the chief role of the states is administrative in nature (Patricios 1986). Land use planning is an administrative task and is thus controlled by the states. The other important player in the planning process is the local government, where most site-specific land use decisions are made. Each state and local government has its own law-making body. This right to self-government is guaranteed under the Basic Law.

German land use planning, from the latter half of the nineteenth century to the mid-twentieth century, was typically performed by local governments. State involvement was limited, and federal involvement was almost non existent. However, this lack of direction began changing in 1960 with the enactment of the *Bundesbaugesetz* (Federal Building Law). This law replaced existing state construction statutes, and it also controlled the manner in which localities performed planning activities. It was following this law that the federal government passed the 1965 Regional Planning Act that provided the framework upon which state and regional planning would be developed.

Land use planning responsibilities follow the interactive relationships between the Federation, states, and local governments (see Figure 5-1). The Federation takes a very broad view; the states, a more focused view; and the local governments, an even more specific/directed focus. Additionally, regional planning has begun to play a major role in the overall German planning process. This regional emphasis has grown in response to an increasing need for comprehensive planning over broader geographic areas. However, the chief planning responsibility remains at the local level. It is important to note that each parcel of land in Germany is controlled by a local government and therefore must conform to local planning regulations, which are in turn set within the context of requirements and overall structure provided by regional, state, and federal regulations. The responsibilities of each of these levels of government for land use planning is briefly described in the following sections.

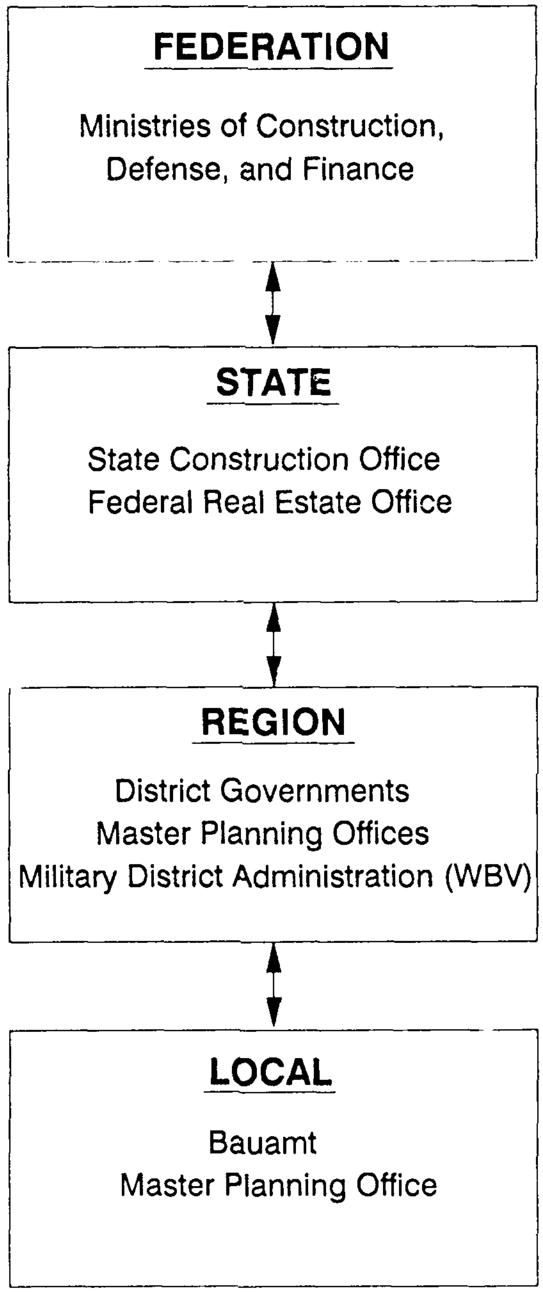

Figure 5-1. German Land Use Planning Hierarchy

Federal-Level Planning and Legislation

The federal government is not involved directly in the planning processes of the state and local governments. The federal government has, however, provided the impetus and organization for planning at these levels through the Federal Building Law and the Regional Planning Act. The Federation involves itself primarily with planning issues that affect the nation as a whole, such as highway construction and environmental protection. Another major concern of the Federation is the management of federally owned properties and construction on those properties. The Ministry of Construction, Ministry of Defense, and Ministry of Finance have put forth broad guidelines for planning and management of federal lands. U.S. Army bases are considered to be a part of these federal lands. Since the federal government can greatly affect the manner in which the Army uses its land, it is important for MILCOM planners to be aware of those federal regulations which could impact on the Army's mission.

State-Level Planning

The State Construction Offices and Federal Real Estate Federal Assets Offices are the pertinent state land use planning offices. State land use plans, or *Landesentwicklungsplaene*, are typically used for guiding development across the state. For example, these plans would include water resource plans, major population trends, delineation of natural and recreation areas, and geographically large developments, e.g. a system of new power plants. All other planning within a state is left to district, regional, or local planning entities. The state does not have direct control over the content of the plans developed by these entities, other than the fact that they must be in accord with the state land use plan. The primary responsibility of the state is to review these lower-level plans from a legal standpoint. The state can reject a lower-level plan only if it is in violation of any law, or if it contradicts the state land use plan.

Regional-Level Planning

Planning at the regional level, or *Raumplanung*, plays an integral part in the overall land use scheme. The regional planning system in Germany can be quite complex, as Figure 5-2 shows. It can be broken down into two primary categories, overall regional planning and specialized regional planning. When dealing with land use changes, Army planners will need to be familiar with the system of overall regional planning. Contained within this system is the regional zoning plan and the regional urban development plan. Army planners will be most concerned with the urban development plan.

A region is geographically smaller than a state but, in most cases, larger than a single city (exceptions being the city-state regions of Hamburg, Bremen, and Berlin). Regions are depicted by appropriate physical and demographic features of the landscape. An example of a planning region is the Heidelberg-Mannheim region that encompasses the area just south of Heidelberg (NuBloch), north to Mannheim, and westward to the Rhein River. This region was formed to manage the metropolis created by the urban areas and to address environmental concerns. The detail of regional plans is much greater than state planning. The Heidelberg-Mannheim region, for example, specifies over forty land use types.

All localities find themselves within a specific regional planning district; therefore regional-level plans may exert considerable influence over local plans. Also, in a type of district planning, local authorities may come together to form planning associations, which are made up of representatives from the local governments. These planning associations can also heavily influence local land usage.

Local-Level Planning

Local-level planning is the most thorough. It provides comprehensive land use planning, zoning, and construction and development planning. While each local entity must comply with general standards set forth by the Federal Construction Code and State Construction Ordinances, it has general freedom to determine whether it wants land use and development plans and, if so, how to implement them. There are two basic plans that are

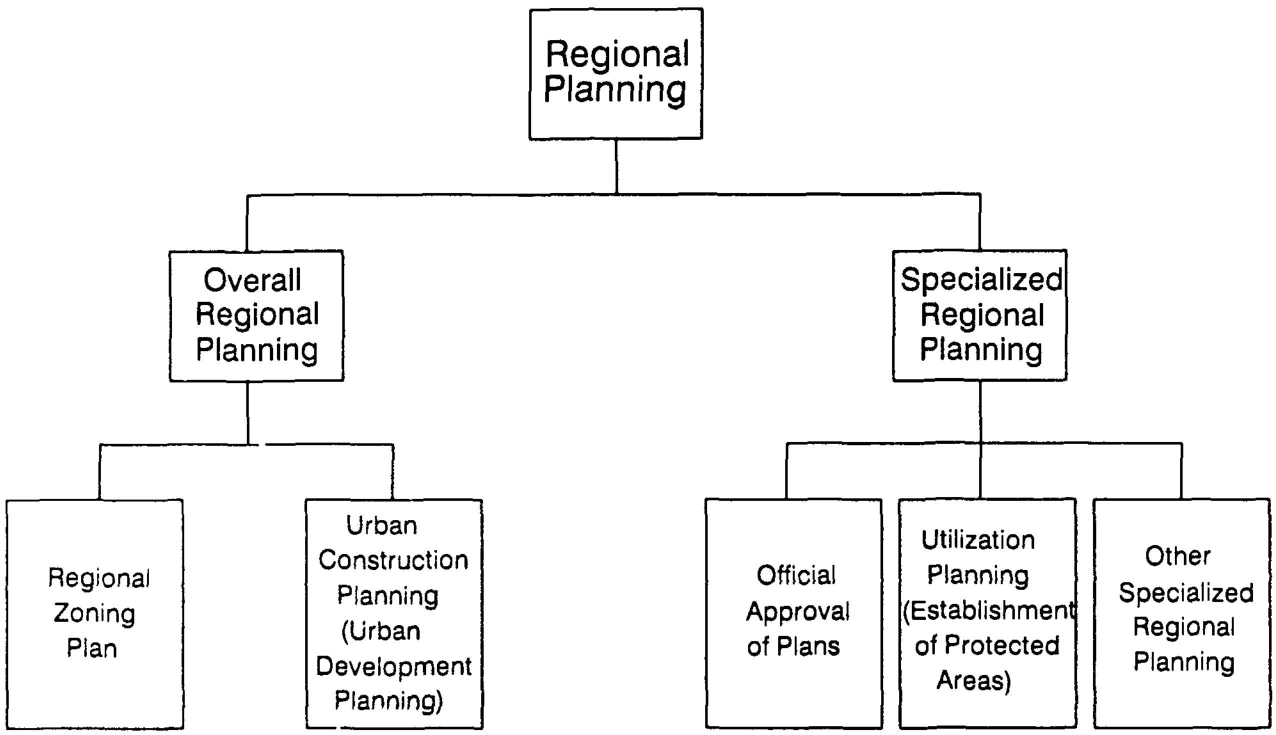

Figure 5-2. Regional Planning in Germany

used at the local level: the local land use plan, or *Flachennutzungsplanung*, and the local zoning plan, or *Bebauungsplanung*. These two plans form the cornerstone for urban planning in Germany. The zoning plan is a legally binding document which, in effect, implements the land use plan. It provides for the site-specific regulation of each parcel of land. It also sets forth site planning guidelines for new construction projects. The land use plan, on the other hand, outlines the general policies of the local government concerning future land usage in its community. It does this by deciding which type of land use should be allowed in what location. The land use plan is completely updated every five to ten years, with smaller revisions occurring as necessary during the interim (Williams 1984).

Additionally, localities may develop an urban development plan, or *Stadtentwicklungsplan*, which is very broad in its coverage. It is not a legal document, but simply a guide for the coordination of such areas as transportation and education (Williams 1984). Army planners will, however, be concerned primarily with the land use and zoning plans when addressing local noise problems.

Another important aspect of local German planning is the concept of "neighbor's consent." It says that if someone wishes to alter his property, he will confer with neighbors to ensure it will not cause a significant hinderance. The Army is considered a "neighbor" and has the right to comment on development surrounding its bases. On the other hand, Germans feel they have a right to comment on changes on Army lands. This type of interaction occurs at meetings such as the Community Relations Advisory Council (CRAC) and during public review of land use plans.

PUTTING THE U.S. IN THE PLANNING LOOP

Now that the German planning process has been examined, it becomes necessary to find out where the Army can best fit into this process.

The typical concern of the Army is with local land use plans. In some cases, requests for exceptions to the existing plan are made; in others periodic updates of the plan will be performed which may result in proposed land use changes which could impact the Army. For example, a tract of land zoned for

agriculture use adjacent to an Army airfield may be considered for rezoning for residential development. Potential for noise-related annoyance should such a rezoning occur certainly exists. In such a situation the Army needs to prevent this land use change from occurring to protect its ability to use the airfield in a conflict-free manner.

Exceptions and alterations to local land use plans like the example above must be publicly announced. Parties wishing to comment or object have thirty days to do so. Failure to provide comments is often seen by local authorities as being tacit approval for the proposed change. Since the Army is a neighbor, its views will be formally requested and can influence the outcome of the decision process. Since Army installations occupy federal lands, the official correspondence between the Army and the locality will be processed through Federal government channels.

The coordination process currently in use is illustrated in Figure 5-3. It begins when an exemption to the local land use plan is proposed. If the proposed change is to occur near a U.S. military installation, the local government will send the proposal to the Federal Ministry of Defense (FMOD). If the proposed change abuts a U.S. installation, the FMOD will then forward the request to its regional Military District Administration (WBV). The WBV must then send the request for a land use change to the Army. Most other general requests for exemption to the local development plan are usually sent to the state's Superior Finance Directorate office, or *Oberfinanzdirektion* (OFD). The OFD must send these proposed changes to any interested U.S. party, including the Army. The Real Estate Field Office (there are seven in Germany) is usually the first U.S. representative to see any proposed changes. If a U.S. Forces Liaison Officer (USFLO) is the initial contact, immediate relay of the proposal is made to the Real Estate Field Office. If the matter is highly controversial, the Real Estate Field Office confers with USAREUR headquarters. In all cases, the Real Estate Field Office contacts the pertinent MILCOMs by phone, and a joint assessment is made. A formal response is then sent from the Real Estate Field Office to either the WBV or the OFD. Copies of the response are also sent to the military community, major command, and USAREUR (USAREUR 1990).

With this process, formation of a complete, thorough response in a thirty day period is often difficult to produce. Given the impact that land use changes can have on the Army, it is important that Army managers find ways in which they can

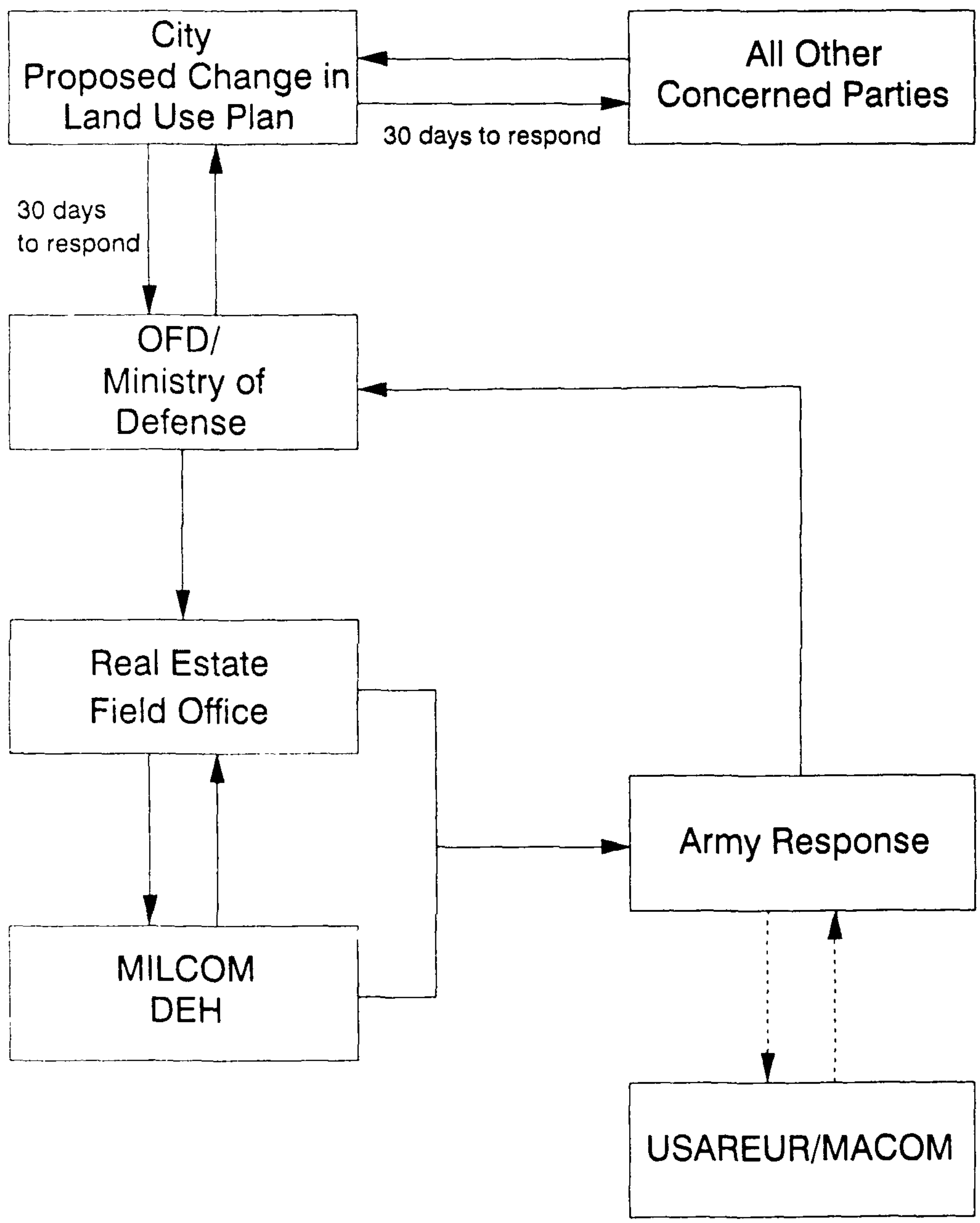

Figure 5-3. Coordination Process for Responding to Proposed German Land Use Changes

supplement the official coordination process and influence the German land use decision making process. Several ideas for supplementing the official process are presented below. They have all proven useful in military ICUZ programs in use in the United States.

Improving Communication: Getting To Know Local Planners, And Exchanging Planning Information

Federal law requires a thirty-day review of land use plans. It also says larger establishments such as utilities and other public agencies should be contacted during the early stages of plan development to ensure that their needs and concerns are addressed before the plan is developed fully. Consider, for instance, a proposed subdivision. The local wastewater utility needs to be contacted up front to see if the present wastewater system can handle the new development. Early discussion is needed because if any insurmountable problems are met, the proposed plan could be either abandoned or revised.

The U.S. Army is considered the type of entity that should receive early notice. If the Army could take advantage of this level of review, the rush involved with the thirty-day review deadline would be eliminated. The legal right to review land use plans at their conception is supported by the German government and should be acted upon by the Army.

The MILCOM planner should remain up-to-date on the latest planning activities in the region. Two-way interaction is required: information from the MILCOM master planner to the local planner and vice versa. This will also ensure that newly developing plans will be exposed to the Army during their early stages (as discussed above).

Communication can be facilitated through a formal exchange of planning memos and announcements. Any existing land use information should be exchanged. Land use plans of the region should be made part of the MILCOM planning library. Minutes of agency meetings can be exchanged to remain abreast of new business. Pertinent land use memos should be routed to each respective planning agency. German land use planning decisions are public domain, and the Army needs to make sure they have access to the decisions. Army land use planning decisions, on the other hand, are not public. Any release of

planning information requires command-level approval. An exchange of this information with local planners (in a manner that preserves necessary military secrets) wouldserve as a good example of information exchange that the German planners could follow.

Less formal interaction could be valuable as well. Meeting with local city planners in various social settings could help bridge communication gaps that often exist between MILCOM personnel and German agencies. Oftentimes, it is this type of meeting that has the best results, as has been found through public affairs efforts (see Chapter 4).

Improving the Quality of Information Used in Planning Decision-Making: Identifying Noise Emission Areas

General noise-planning guidelines for urban areas are provided in DIN 18005. In addition, the Federal Emission Control Act of 1974, implemented by the Technical Directive Concerning Protection Against Noise (TA Laerm), establishes *maximum noise* levels for industrial, commercial, housing, and mixed areas and thus regulates the noise emissions of those commercial facilities and other installations (including military installations) requiring a license to operate. Emission control agents assess noise levels and, with consideration of surrounding land uses, assign an allowable level of noise. Due to the NATO Status of Forces Agreement, the USAREUR forces are mandated to comply substantively with German environmental laws; however, they are not subject to the procedural aspects (licensing and reporting requirements) of these laws. This means that the Army may employ its own methods and procedures in order to comply with these protection standards.

The implication of these laws for the Army is that they provide a useful mechanism for preventing noise sensitive land uses from coming into areas impacted by high noise levels. For the laws to work effectively, however, officials need to have quantitative data which demonstrate that the areas in question are noise impacted. German authorities thus point out that site specific noise-level measurements, if introduced during the early stages of a proposed land use change, would add great weight to Army concerns that are expressed.

One such action that the Army can take is to identify areas on its MILCOM site maps where substantial amounts of noise are made as a result of training or base operations activities, and where it could be expected that such noise will extend across installation boundaries into civilian lands. Noise contours or similar types of noise measurements (discussed in Chapter 2) are useful for describing potential noise impacted areas. Sharing such information with local planning agencies could prevent development in noise impacted areas from being proposed in the first place. Information on noise measurements and analyses are available through acoustical experts identified in Appendix A.

Following-Up on Past Comments

The Army has commented on many past German land use decisions. In some cases, comments were acted upon, in others they were not. Useful information could be gained if it was known why comments were or were not considered. Insight into successful format and scope of review comments will aid in tailoring future approaches to land use planning input.

CHAPTER SUMMARY

The highlights of land use planning in Germany as presented in this chapter are as follows:

* A well-established system governs German land use.
* The most important levels of planning occur at the regional and local levels.
* The Army is a "neighbor" in the planning process. As such it has the right to make its views known in land use issues that affect its interests.
* Formal review processes, while necessary, are often lengthy and can fail to provide timely input into planning decisions. MILCOM planners can supplement the formal coordination process by:
    * fostering communication with local planning agency staff
    * exchanging planning information
    * becoming knowledgeable about local planning issues
    * identifying noise emission areas

* determining successful and unsuccessful features of Army input into prior land use issues.

ILLUSTRATIVE EXAMPLE: AUKAMM HOUSING-ROAD CONSTRUCTION

The following example illustrates clearly the problems many U.S. Army and local German planners are confronted with when dealing with a land use decision. The example is concerned with a proposed road construction project the Germans wanted to build. In order to do so, they would have to acquire U.S. installation property. It took over nine years for the two sides to come to a mutual agreement on the project. A brief portion of the full nine year dialogue between the U.S. and Germany is presented below to show just how lengthy the process can become. While the example is not of a proposed exception to a land use plan, it is illustrative of the amount of time involved in an exception case.

In March of 1978, the Wiesbaden Property Office sent a proposal to the local office of the *Bundesvermoegensamt*, or BVA, concerning a planned road construction project near the Aukamm Housing Area (AHA). This project would mean the demolition of Buildings 21 and 23 in the area. The German Republic would have to acquire this land from the U.S. Army. The initial proposal was forwarded from the BVA to the REA-FK two weeks later. This letter was then sent to the U.S. V Corps one month later. The letter was then sent to USMCA Wiesbaden from V Corps approximately two weeks later, approving the German proposal. However, in July, USMCA Wiesbaden advised against approval, and recommended waiting until the city had its hearings. V Corps then sent their support for this decision to USAREUR approximately two weeks later on July 20. USAREUR then sent its endorsement to the German government on August 15, 1978. On that same day USAREUR sent to V Corps a letter requesting to know what position the community wanted to take at the public hearings. Thus began an even more lengthy, detailed process which would not near completion until August 1987.

As this example shows, it can be slow and cumbersome for the Army to develop a formal position on a land use or development decision. While, in this instance, the German government wanted to obtain land located on a U.S. installation, the formal response time to a proposed land use exemption is

roughly the same. In this example, the response time took six months from the initial proposal by the local Wiesbaden Property Office to the final authorization by USAREUR. A formal Army response to a proposed land use change has also been approximately six months. As can be seen, the thirty-day deadline is almost impossible to meet under normal circumstances. This makes it necessary for the Army to expedite its response time after receipt of any proposed changes to the local land use plan.

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CHAPTER 6
AIRFIELDS

Blade slap produces low-frequency throbbing noise
Ground run-up is an annoying, continuous noise source
Schedule during noisy times and fly over noisy areas
Avoid the blade slap zone

GENERAL SETTING

This chapter presents issues surrounding noise management at airfields. Helicopters are the dominant mode of air travel of the U.S. Army in Germany. Noise generated both in flight and on the ground (run-up, refueling, maintenance, testing, etc.) are sources of noise complaints. Many complaints are directed toward nighttime activity. Development in buffer-zone lands adjacent to airfields has intensified the problem.

PROBLEM DEFINITION

Nature of Airfield Noise

The major sources of helicopter noise originate from rotor blade slap, tail rotor rotation, main rotor rotational, turbine/ piston engines, and transmission (DOD 1978). Air movement in the path of rotor blades is the dominant noise characteristic. The rotor blades create powerful whirlwinds of air -- the vortex. When one blade's vortex is penetrated by another blade, locally high velocities occur causing transonic shock. This phenomenon, referred to as blade slap, is the characteristic low-frequency throbbing sound that helicopters make. Blade slap is most prominent during descent and high-speed maneuvers. The transmission engine produces a high-frequency, comparatively quiet sound (DOD 1978).

Activities related to run-up and other ground operations have considerable noise impact in the airfield region. Refueling of running aircraft contributes to many noise problems. The impacts

are magnified when general aircraft are lined up, running and waiting to refuel. Significant attenuation from ground absorption, building absorption, etc., causes the level of peak loudness to be diminished (Goff and Novak 1977). However, the nature of the sound is continuous compared to short-event flyovers. Consequently, annoyance from ground-based activity is generally considered more intrusive to human activity.

Airfield Noise Measurements

Development of an effective noise management plan requires an assessment of the noise patterns being produced at your installation. A detailed assessment conducted by acoustical experts identified in Appendix A is highly recommended. They have the tools, computer technology, and expertise needed to provide accurate results.

Assessment Tables

Included in this section are a series of tables that provide a range of airfield activities, associated noise levels, and general community annoyance associated with the noise levels. The primary purpose of these tables is to provide you with a general way of assessing the likelihood that noise from activities taking place at your installation may be producing annoyance in the surrounding community. These tables are not a replacement for an actual noise assessment. You can use the tables to get a feel for the level of noise heard at various distances from the installation. Please understand that the tables were produced under very specific conditions and should serve only as gross approximations to your situation. Proper application of the tables is for low-level judgment such as "Well, I can see why there are so many complaints in that neighborhood" or, "We haven't had problems in the past, but with this increase in activity, maybe we ought to have the acoustical engineers come in to conduct a detailed assessment."

The values in the tables are the LEQ levels produced by a range of flight activities at specified distances. Remember from Chapter 2 that LEQ is the average sound level over a specified period of time, and is therefore relatively insensitive to single events that may cause a particularly high level of annoyance. For

example, a flyover during a highly anticipated outdoor performance of the national symphony would be considered highly annoying. But because the flyover is averaged with other quieter times of the day, the LEQ measure reveals a less severe noise level. This is the poir . though LEQ is a widely used planning tool, blind application can sometimes hide a more severe noise situation.

Noise is noticeable below 50dB (35 dB for night) but is typically considered a small problem, thus there is usually a very low occurrence of complaints and annoyance. Between 50dB and 60dB (35dB - 45dB for night) you would expect scattered complaints and annoyance, which are typically considered a moderate problem. This is more of a jump than it appears -- remember a 10dB increase in a single noise event is a perceptual doubling of noise. Substantial problems come about between 61dB and 70dB (46dB - 55dB for night). A very significant portion of the population is annoyed at this range. Anything above 70dB (55Db for night) is considered an immense noise problem and will likely result in vigorous community reaction.

Flyover noise estimates for six types of helicopters are shown in Tables 6-1 through 6-6 and hot refueling is shown in Table 6-7. The technical notes and underlying assumptions for these tables can be found in Appendix C.

MITIGATION MEASURES AT AIRFIELDS

This section is organized into subsections that cover noise abatement for ground activities and flight activities, respectively. Mitigation at the source, path, and receiver is presented.

Ground-Related Noise Mitigation

Ground-Related Mitigation: Source

Action at the source is the primary noise attenuation method for ground-related activity. A majority of the activity, e.g., refueling and run-up, is necessary and cannot be terminated. The main consideration should be toward minimizing activity during the nighttime and German holidays. Over one-third of the

LEQ Day (dB)

Number of Flyovers	Altitude in Meters			
	150	300	900	3000
50	69	64	55	45
200	75	70	61	51
500	79	74	65	55
1000	82	77	68	58

LEQ Night (dB)

Number of Flyovers	Altitude in Meters			
	150	300	900	3000
5	62	57	48	38
50	72	67	58	48
200	78	73	64	54
500	82	77	68	58

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 6-1. Noise from the CH-47 Helicopter

LEQ Day (dB)

Number of Flyovers	Altitude in Meters 150	300	900	3000
50	67	61	52	42
200	73	67	58	48
500	77	71	62	52
1000	80	74	65	55

LEQ Night (dB)

Number of Flyovers	Altitude in Meters 150	300	900	3000
5	60	54	45	35
50	70	64	55	45
200	76	70	61	51
500	80	74	65	55

		Day (dB)	Night (dB)
Small problem		Less than 50	Less than 35
Moderate problem		50 - 60	35 - 45
Substantial problem		61 - 70	46 - 55
Immense problem		71 and above	56 and above

Table 6-2. Noise from the UH-1 Helicopter

LEQ Day (dB)

Number of Flyovers	Altitude in Meters: 150	300	900	3000
50	61	56	49	39
200	67	62	55	45
500	71	66	59	69
1000	74	69	62	52

LEQ Night (dB)

Number of Flyovers	Altitude in Meters: 150	300	900	3000
5	54	49	42	32
50	64	59	52	42
200	70	65	58	48
500	74	69	62	52

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 6-3. Noise from the UH-60 Helicopter

LEQ Day (dB)

Number of Flyovers	Altitude in Meters: 150	300	900	3000
50	66	60	51	40
200	72	66	57	46
500	76	70	61	50
1000	79	73	64	53

LEQ Night (dB)

Number of Flyovers	Altitude in Meters: 150	300	900	3000
5	59	53	44	33
50	69	63	54	43
200	75	69	60	49
500	79	73	64	53

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 6-4. Noise from the AH-1 Helicopter

LEQ Day (dB)

Number of Flyovers	Altitude in Meters: 150	300	900	3000
50	59	54	44	33
200	65	60	50	39
500	69	64	54	43
1000	72	67	57	46

LEQ Night (dB)

Number of Flyovers	Altitude in Meters: 150	300	900	3000
5	52	47	37	26
50	62	57	47	36
200	68	63	53	42
500	72	67	57	46

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 6-5. Noise from the AH-64 Helicopter

LEQ Day (dB)

Number of Flyovers	Altitude in Meters			
	150	300	900	3000
50	59	54	46	37
200	65	60	52	43
500	69	64	56	47
1000	72	67	59	50

LEQ Night (dB)

Number of Flyovers	Altitude in Meters			
	150	300	900	3000
5	52	47	39	30
50	62	57	49	40
200	68	63	55	46
500	72	67	59	50

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 6-6. Noise from the OH-58 Helicopter

LEQ Day (dB)

Number of Aircraft	Distance From Refueling Location (meters)			
	150	300	600	900
1	51	40	29	22
2	59	48	37	31
4	65	54	43	36
8	70	59	48	42

LEQ Night (dB)

Number of Aircraft	Distance From Refueling Location (meters)			
	150	300	600	900
1	54	43	32	25
2	62	51	40	34
4	68	57	46	39
8	73	62	51	45

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 6-7. Noise from Hot Refueling

MILCOMs in Germany have responded to ground-run-up-related complaints by regulating flight times (Dunning and Nolton 1988). Some flight restrictions have been made part of standard operating procedures (SOP), while others are less formal. Inclusion of restrictions in an SOP is probably the more irrefutable approach. Local activities should be considered as well and can be placed in the SOP. For example, the Annual Spargel Festival (or something similar) may be very important to the local residents. Special attention paid to such events in terms of reduced activity has been greatly appreciated by the German public in the past.

As the sound characteristics of individual aircraft become familiar, "noisy" aircraft can be maintained/tested during appropriate busy hours of the day. Consequently, the impact of the noise would be less evident, as it would "blend in" with the normal temporal noises of the city. For example, the UH60 helicopter runs much more quietly than the UH1. Scheduling the maintenance and testing of the UH1 for late morning (a busy time of day) could minimize the noise impact while serving the mission goal.

Mufflers are available to reduce engine noise (HAI 1983). Piston-power engines can be especially noisy. Light mufflers that quiet the "barking" of an unmuffled piston engine are installed directly on the muffler stacks. Larger mufflers must be mounted to the fuselage. Noise-reduction effectiveness of mufflers varies significantly. Structure-mounted mufflers typically provide just less than twice the sound reduction as the stack-mounted types. Costs, both economic and performance, are major factors when considering a muffler.

Ground-Related Mitigation: Path

As touched on earlier, noise attenuation from the ground and buildings can be significant. Thus, run-up pad location at the airfield is important (see Figure 6-1). Orientating the run-up pad with buildings and maximum space between the pad and residential land will provide attenuation. One may be tempted to construct a barrier wall in an attempt to provide the same type of attenuation. In general, barrier walls are not recommended for low frequency noise because the sound wave "jumps" the barrier wall. Helicopter noise is absorbed in buildings and the ground, which are much thicker than a barrier wall.

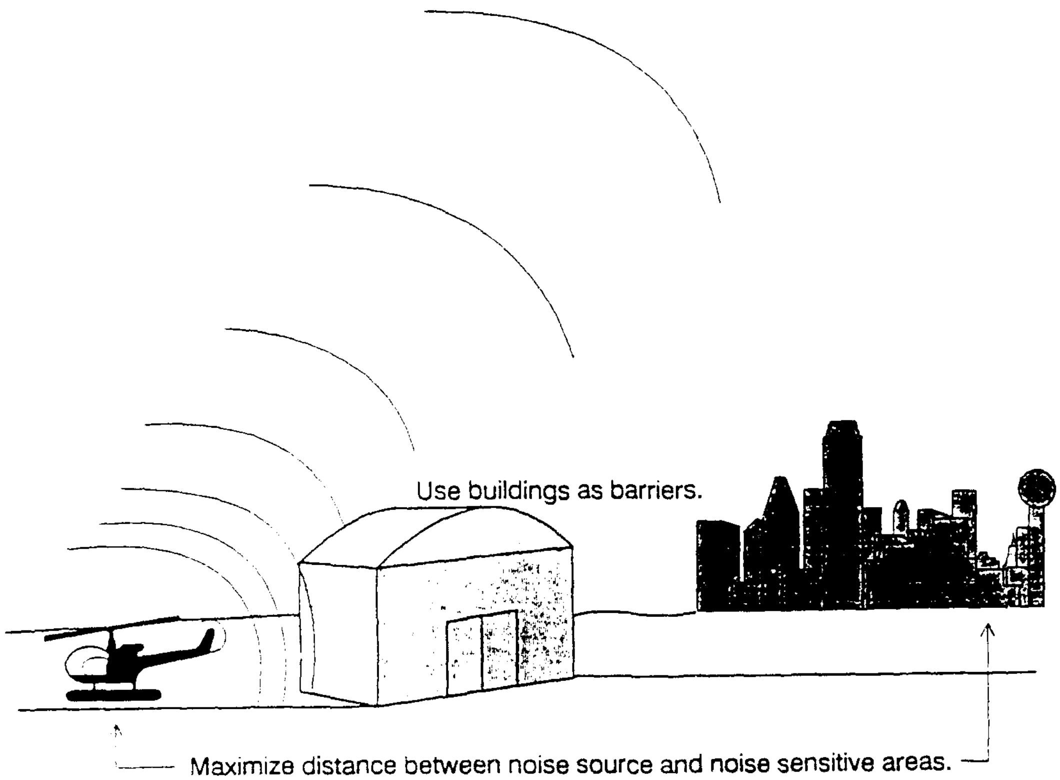

Figure 6-1. Using Existing Buildings as Noise Barriers

Ground-Related Mitigation: Receiver

In a "best case" situation, noise abatement through land use planning and zoning will put the receiver out of range of unwanted noise. The reality in Germany is that this approach alone is not sufficient. A number of architectural technologies are available that provide noise protection for those inside the structure (PMCL 1988). Up to 50 dB of noise reduction can be obtained with the proper construction and architectural strategy, although such noise relief will only be experienced by those indoors.

One architectural strategy is to design the garage/storage buildings to be between the living area and the noise source. In

the same vein, noise-sensitive rooms (e.g., bedrooms, study) could be placed on the end of the house farthest from the noise source. Horseshoe-shaped houses have been found to weaken noise from many directions (VDI 2718 1975). These types of considerations can be suggested by MILCOMs for newly constructed developments. Not only do suggestions such as these at CRAC meetings reduce noise at some homes, but they also serve as goodwill gestures that demonstrate concern.

Construction techniques can be used to attenuate sound also (see Table 6-8). Some of these techniques can be used after the structure has been built. Noise-proofing with the proper construction and architectural strategy could be provided, although such noise relief will only be experienced by those indoors. This would be a very practical management option if the number of structures involved is small.

Noise complaints are very seasonal. In cool weather when windows are closed, fewer complaints are made as compared to warm weather seasons when windows are open. This should certainly be noted if subsidizing soundproof windows is being considered, because the resultant attenuation will likely be seasonal as well!

In-Flight-Related Noise Mitigation

In-Flight-Related Mitigation: Source

There are many ways that the noise impact can be reduced at the source. As in the ground-based section, limiting nighttime activity and attention to German holidays is the most effective single abatement measure. Another general abatement measure is to define noise-sensitive areas and publish these defined areas formally to all pilots and controllers via SOPs or other comparable modes of communication. Noise reduction for flying is addressed extensively in the Fly Neighborly Guide by the Helicopter Association International (1983). This document is a must for those interested in minimizing noise impact from helicopter activity. Tactical training manuals may also be a valuable source for tips on flying "quietly." Provided below are some noise-reduction tips for departure, altitude, flight patterns, routes, and approach (HAI 1983, PMCL 1988a, DOD 1978).

Building Component	Construction Measure
Walls	Increase mass Use "dead" air space Increase airspace width (between walls) Increase airspace length (stud interval) Use staggered studs Seal cracks and edges Use insulation blankets Give special attention to openings; electrical outlets, medicine cabinets, etc. Use resilient materials to hold studs and panels together Use acoustic coating
Roofs	Increase mass Seal cracks and edges
Ceilings	Use insulation blankets Use non-fixed suspension methods Use acoustical coatings
Floors	Increase mass Block off all joists (prevents noise from traveling over and under walls) Use resilient supports between joists and floor
Windows	Use sealed windows Increase glass thickness Use double glazed windows Increase volume of "dead" airspace in double glazed windows
Doors	Use solid core doors Use doorframe gaskets
Interior Design	Use heavy drapes Use heavy carpets Use acoustical ceiling treatment

Table 6-8
Construction Techniques to Minimize Outside Noise
Source: DOD (1978)

Departure, as compared to approach, is a relatively quiet operation because blade slap is not a big problem. Ground-noise exposure can be minimized with a steeper ascent. This, in conjunction with a smooth transition to forward flight, optimizes noise reduction during takeoff. Noise-sensitive areas, such as residential zones, schools, etc., should be avoided during takeoff. A noisy area, such as an industrial park, is a good alternative for departure.

Noise level is minimized as flight altitude increases. Realizing low-level flying is an integral part of training, pilots should attempt to increase altitude to 2,000 feet or greater when approaching noise-sensitive areas. Conversely, one should recognize as altitude increases so does the actual area which is affected by the inflight noise. Thus, there are noise reduction tradeoffs that need to be considered.

The tail rotor is on the left side of helicopters. Consequently, the left side produces more noise. A flight pattern with noise-sensitive areas to the right will minimize noise exposure. High g-force turns can produce blade slap and should be avoided when noise is a concern. Noise exposure is greater on the outside of the turn, thus noise-sensitive areas should be kept on the inside.

Flight routes should routinely follow highways and railroads, where the impact of the helicopter noise "blends in" with the highway/railroad noise. Whenever possible noise-sensitive areas should be avoided. If several low impact flight routes are available, usage should be distributed evenly and/or strategically to minimize noise concentration in one area.

The approach/descent component of a flight produces the greatest noise impact, mainly because it is conducive to blade slap. Pilots should try to keep the airfield between the aircraft and noise-sensitive locations. If this is not possible, landing at a steeper angle will reduce the area of the noise contour, which is often referred to as the "noise footprint" (Figure 6-2). Blade-slap zones are defined by certain combinations of velocity and rate of descent. The blade-slap zone for light helicopters is shown in Table 6-9. Pilots should avoid the blade-slap zone to minimize noise. This is accomplished by using a glide slope with a slightly higher rate of descent than normal.

Similar ascent/decent considerations should be made when operating fixed-wing aircraft (DOD 1978, Cline 1986,

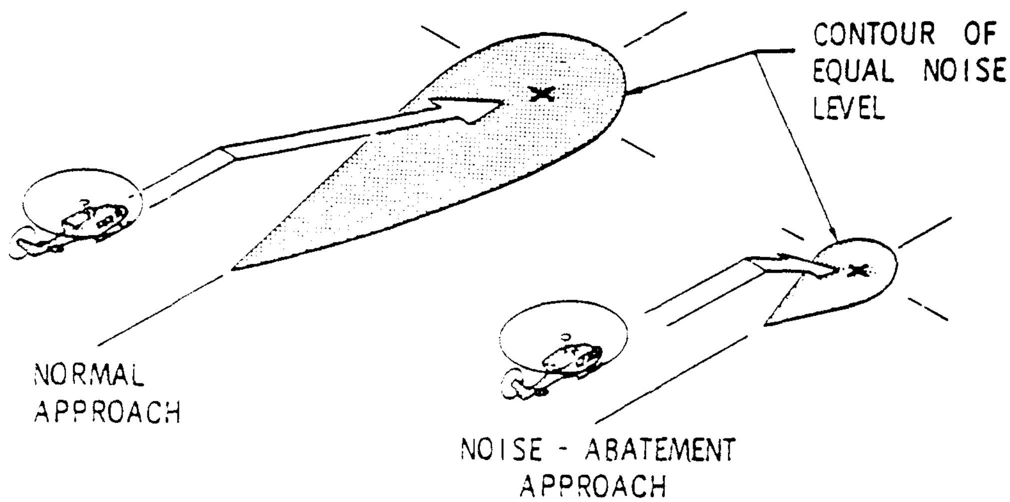

Figure 6-2. "Quieter" Landing Technique
Source: Helicopter Association International (1983)

Bragdon 1983). Lower power climbs reduce intense thrust noise during take-off--conversely, higher altitudes take longer to be reached. During approach, use of maximum glide curgle will reduce noise impacts. Limiting use of reverse thrust will lessen noise inpacts, but requires longer runways.

In-Flight-Related Mitigation: Path

Noise attenuation at the path is very difficult. (A 2,000-foot-high barrier wall is not very practical). However, special attention to atmospheric conditions can aid in reducing noise (HAI 1983). Specifically, temperature and wind have significant impact on noise travel. Using these in the interest of noise can minimize noise impacts.

Wind carries sound in the direction it is blowing. Understanding the characteristic wind directions of the region of flight will provide opportunities during the day to fly with minimum annoyance. Inland areas, for example, have stronger daytime winds as compared to nighttime. This may allow a quiet flight route on the downwind side of an urban area. Strong winds provide background noise that masks other noise and reduces annoyance.

Rate of Descent Ft/Min	Airspeed of Blade Slap Miles/Hr
Less than 250	No Blade Slap
250	75-95
375	70-103
500	72-100
More than 625	No Blade Slap

Table 6-9. Blade Slap Zone During Descent for Light-Helicopters
Source: Helicopter International Association (1983)

Sound moves more quickly in higher temperatures. Normal temperature gradients tend to decrease with altitude. Consequently, under normal temperature gradient conditions, sound waves bend upward away from the ground/population. Attention to the temperature gradient, which peaks near noontime, can provide significant attenuation.

Some days temperature increases with altitude; this is termed an inverse gradient. Such a condition can cause very adverse noise conditions on the ground. Flight activity should be minimized during inverse gradient days.

In-Flight-Related Mitigation: Receiver

Methods for reduction of noise at the receiver would be the same as discussed in the ground activity section.

CHAPTER SUMMARY

In review of the airfield noise management, these are a few of the highlights:

* Match noisy activities with noisy times of the day and noisy locations.

* Use MILCOM structures, such as garages and warehouses, as noise barriers.
* Minimize nighttime activity when possible; avoid high activity during German holidays and celebrations.
* Noise-sensitive housing can reduce indoor noise up to 50 dB.
* Read Fly Neighborly Guide.
* Avoid the "blade-slap" zone.
* Flight routes should avoid noise-sensitive areas; follow roadways whenever possible.
* Maximize altitude, especially over noise-sensitive areas; adjust flight plans for weather conditions.

ILLUSTRATIVE EXAMPLE: COLEMAN AIRFIELD, MANNHEIM

The Coleman Airfield services about 90,000 helicopter flights per year. The noise problems peaked about 1983, for which a mitigation plan was developed.

Upon realizing the noise problem was something that could no longer be ignored, an aggressive complaint management system was established. A complaint switchboard was developed with German-speaking operators to ensure proper interpretation. The complaints were fielded and recorded. The date, time, complainant's name and address, identification of the aircraft, and follow-up action were recorded for each instance. When possible, personal contacts were made to discuss the problem with the complainant.

The complaint data were used to identify trends. Areas of concentrated complaints were established and the associated military activities were revealed. The necessity of the noise-making activity was determined -- if it could be changed with marginal mission impact, then changes were made.

The main problem was found to be helicopter flyover noise. Aircraft flying over residential and other noise-sensitive areas were the most often cited complaint. The UH-1 was also found to produce a higher level of noise than most of the other aircraft. Ground run-up activity was found to be a noise culprit as well. Another trend identified was that more complaints are made during warm weather, because windows are usually open.

The airfield manager and public affairs officer considered several options. During close examination of flight patterns, they found that pilots were generally following noise-abatement corridors, i.e., following the autobahn, but they were cutting corners. This small deviation caused most of the complaints and annoyance. Pilots are now instructed to strictly follow the specified fight patterns. Routings for approaches and takeoffs were also changed to limit exposure to noise-sensitive areas. Rerouting was conducted gradually -- to develop the most desirable route and minimize the deviation to the training mission.

Another option considered was a barrier wall for run-up noise. After close examination of the associated costs and benefits, it was found not to be a cost-effective option.

One of the biggest assets to the noise-mitigation program was enhanced public relations. Information and public meeting campaigns were carried out. Keeping close contact with the communities through CRAC meetings served the interests of both the Army and the people. In an assessment of USAREUR's noise management program, The Deputy Chief of Staff for Host Nations Activities praised the public affairs effort at Coleman Airfield:

> Mannheim [Coleman Airfield] and Hanua, for example, both have installations which operate busy and noisy airfields. But both have an active and effective public relations program, both successfully manage conflict rather than react to crisis. We should find out what they do right and adopt their program in other communities as well.

The noise management program at Coleman Airfield has been quite effective. Complaints have fallen from about three per month to three per year. Continuing active complaint management and public information programs keep communication lines open and ensure that interests of both parties are met.

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> ***Generator unit noise is typically mid-high frequency***
> ***Make noise away from populace***
> ***Barriers make sound travel farther***
> ***Enclosures trap noise***

GENERAL SETTING

This chapter addresses noise associated with general base operations. Noise from motor pools, generators, and refrigeration equipment are the chief irritants in base operations. Nearly half the MILCOMs in Germany consider base operations to present at least moderate noise problems (Dunning and Nolton 1988). The main contributing factor is that many motor pools and Kasernes are situated in residential areas where exposure to the populace is heightened.

PROBLEM DEFINITION

Nature of Base Operations Noise

Noise from generators and air-conditioning units are not usually considered startling or excessively loud, but because they are typically represented by pure tones, they are considered quite annoying. Motor pool noise is quite varied. Typical sounds from motor pools are impulse-type noise from hammers, "whining" power tool noise, and engine "revving" from maintenance and transportation activity. Sometimes, test tracks are used that can present noise problems. Any of these activities that take place at night make the problem worse.

Base Operations Noise Measurements

Development of an effective noise management plan requires an assessment of the noise patterns being produced at your installation. A detailed assessment conducted by acoustical

experts identified in Appendix A is highly recommended. They have the tools, computer technology, and expertise needed to provide accurate results.

Assessment Tables

Included in this section are a series of tables that provide noise levels for generators and for a typical motor pool, and general community annoyance associated with the noise levels. The primary purpose of these tables is to provide you with a general way of assessing the likelihood that noise from activities taking place at your installation may be producing annoyance in the surrounding community. These tables are not a replacement for an actual noise assessment. You can use the tables to get a feel for the level of noise being produced at various distances from the installation. Please understand that the tables were produced under very specific conditions and should serve only as gross approximations to your situation. Proper application of the tables is for low-level judgment such as "Well, I can see why there are so many complaints in that neighborhood"; or, "We haven't had problems in the past, but with this increase in activity, maybe we ought to have the acoustical engineers come in to conduct a detailed assessment."

The value used in each table is LEQ and is produced by examining a range of operation times at specified distances. Remember from Chapter 2 that LEQ is the average sound level over a specified period of time, and is therefore relatively insensitive to single events that may cause a particularly high level of annoyance. For example, running a generator for just 15 minutes directly adjacent to a cemetery during a funeral service would be considered highly annoying. But because the generator noise may be averaged with other quieter times of the day, the LEQ measure may reveal a less severe noise level. The point here: though LEQ is widely used as a planning tool, blind application can sometimes hide a more severe noise situation.

Noise is noticeable below 50dB (35dB for night) but is typically considered a small problem, thus there is usually a very low occurrence of complaints and annoyance. Between 50dB and 60dB (35dB - 45dB for night) you would expect scattered complaints and annoyance, which are typically considered a moderate problem. This is more of a jump than it appears -- remember a 10dB increase in a single noise event is a perceptual

doubling of noise. Substantial problems come about between 61dB and 70dB (46dB - 55dB for night). A very significant portion of the population is annoyed at this range. Anything above 70dB (55dB for night) is considered an immense noise problem and will likely result in vigorous community reaction.

Tables 7-1 through 7-8 illustrate the LEQ levels for a variety of generator sizes. Those generators with very similar output levels were combined in several of the tables. The technical notes concerning the creation of the generator tables are provided in Appendix C. Also in Appendix C are the notes for Table 7-9 (Noise from a Motor Pool). The motor pool table was developed using noise readings taken from Spinelli Barracks, and is intended to be representative of motor pool noise in general.

MITIGATION MEASURES FOR BASE OPERATIONS

Noise Mitigation for Base Operations: Source

Much of the sound-generating activity from base operations cannot be avoided. Trucks must ship goods and equipment, air-conditioning units must run, etc. One approach to limiting annoyance is to try to coordinate the loudest activities at noisy times of the day. Higher levels of background noise (e.g., traffic) dulls the base operations noise because it is made less apparent.

If groups of trucks (or other types of vehicles) are scheduled to come in for repair, efforts toward scheduling all of them to be driven in at once could limit the noise exposure time. Sensitivity to German quiet hours (1300-1500) should be maintained.

At the risk of confusing the issue, grouped transportation could "backfire." One negative affect is that it may congest traffic.

Oftentimes, extra attention of any kind is construed as a noise problem. ("That convoy of tanks kept me from my appointment ... and besides, they're too loud!!") Some MILCOMs have found it best to "trickle" vehicles from point A to point B, which minimizes the noise impact during transport.

The point to be taken from all this is that transport activity should be looked at carefully. Consider an array of scheduling

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	53	47	35	29
4	56	50	38	32
8	59	53	41	35
16	62	56	44	38

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	56	50	38	32
4	59	53	41	35
8	62	56	44	38

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-1. Noise from 0.5, 1.5, and 3.0 Kilowatt Generators

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	56	50	38	32
4	59	53	41	35
8	62	56	44	38
16	65	59	47	41

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	59	53	41	35
4	62	56	44	38
8	65	59	47	41

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-2. Noise from 5.0 (gas and diesel) Kilowatt Generators

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	55	49	37	31
4	58	52	40	34
8	62	55	43	37
16	64	58	46	40

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	58	52	40	34
4	62	55	43	37
8	64	58	46	40

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-3. Noise from 10.0 (gas and diesel) Kilowatt Generators

LEQ Day (dB)

Hours/Days	Distance from Generator (meters) 50	100	400	800
2	56	50	38	32
4	59	53	41	35
8	62	56	44	38
16	65	59	47	41

LEQ Night (dB)

Hours/Night	Distance from Generator (meters) 50	100	400	800
2	59	53	41	35
4	62	56	44	38
8	65	59	47	41

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-4. Noise from 15.0 (housed) and 30.0 (housed) Kilowatt Generators

LEQ Day (dB)

Hours/Days	Distance from Generator (meters) 50	100	400	800
2	62	56	44	38
4	65	59	47	41
8	68	62	50	44
16	71	65	53	47

LEQ Night (dB)

Hours/Night	Distance from Generator (meters) 50	100	400	800
2	65	59	47	41
4	68	62	50	44
8	71	65	53	47

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-5. Noise from 60.0 (housed) and 72.0 (housed) Kilowatt Generators

LEQ Day (dB)

Hours/Days	Distance from Generator (meters) 50	100	400	800
2	60	54	42	36
4	63	57	45	39
8	66	60	48	42
16	69	63	51	45

LEQ Night (dB)

Hours/Night	Distance from Generator (meters) 50	100	400	800
2	63	57	45	39
4	66	60	48	42
8	69	63	51	45

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-6. Noise from a 100.0 (housed) Kilowatt Generator

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	66	60	48	42
4	69	63	51	45
8	72	66	54	48
16	75	69	57	51

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	69	63	51	45
4	72	66	54	48
8	75	69	57	51

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-7. Noise from a 100.0 (unhoused) Kilowatt Generator

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	68	62	50	44
4	71	65	53	47
8	74	68	56	50
16	77	71	59	53

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	71	65	53	47
4	74	68	56	50
8	77	71	59	53

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-8. Noise from a 200.0 (housed) Kilowatt Generator

LEQ Day (dB)

Hours/Days	Distance from Motor Pool (meters) 50	100	400	800
2	56	50	38	32
4	59	53	41	35
8	62	56	44	38
16	65	59	47	41

LEQ Night (dB)

Hours/Night	Distance from Motor Pool (meters) 50	100	400	800
2	59	53	41	35
4	62	56	44	38
8	65	59	47	41

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 7-9. Noise from a Motor Pool

options, i.e., grouped transportation, "trickle," etc. Be sure to take into account quiet hours. Standard operating procedures often dictate permissable blocks of time for convoys.

Distance between noise source and sensitive areas should be maximized. Convoys and freight haulers should avoid residential areas whenever possible. Test tracks and mobile generators should be located as far as possible from the populace. Remember, space provides quiet: each doubling of distance between the source and receiver reduces the (point source) noise approximately 6 decibels.

Nighttime "roll-outs" are very annoying. They are a necessary segment of training and preparedness, but proper scheduling can minimize the noise impact. If possible, they can be scheduled during cold winter months when windows are typically closed. Major noise-making events should be scheduled far enough apart so the public has a chance to "forget" the last one. "Roll-outs" could be followed by intense public relations campaigns or events. Again, try to think things through and develop a list of alternatives.

Test tracks should be used only when necessary. Testing vehicles in normal traffic (assuming safety is not a factor) will diminish noise-generated attention directed to the installation.

Generation-type units mounted to floors, walls, and slabs vibrate and can cause a loudspeaker effect (DOD 1978). To absorb the vibration-created noise, rubber mounting blocks (or a similar type of mount) will reduce this noise considerably. Loose sheet metal shields and housing should be sought out and tightened.

There are commercially available generators that are quieter than many of those the Army presently uses. Any efforts in this direction, whether approved or not, should be advertised to the German public. The mere gesture of looking into something like this often "quiets" the situation (see Chapter 4 for expansion of this notion).

The feasibility of introducing quieter generators is presently being examined. The Army's Logistic equipment Directorate, Power Generation Division, has been researching generator noise intensely. They have made significant progress and expect to replace a majority of the existing "loud" generators with units that produce a much lower level of noise (70 dB(A) or less at 25').

Commercially available power should be considered. In some cases, permanent and semi-permanent equipment powered

by mobile generators could be hooked up to the local municipal source. In such a case, generator noise would be greatly reduced.

Noise Mitigation for Base Operations: Path

Barriers are the most common approach to abating base operation-related noise at the path. Generators and refrigeration-type units (referred to now simply as generation-type units) produce distinctive, relatively high-frequency "humming" noise that can readily be attenuated by barrier walls or enclosures.

Sometimes a situation will call for the construction of an actual noise-attenuation barrier. The expertise of acoustical engineers identified in Appendix A is required in this instance. Many MILCOMs have constructed noise barrier walls and received security as well as noise-attenuation benefits. Presenting multipurpose objectives can strengthen the justification for the construction of a barrier wall. Other aspects of a barrier to consider are maintenance, aesthetics, and safety.

Barriers located in the line of sight of the source and receiver transmit, reflect, and diffract sound waves (see Figure 7-1). The barrier wall impedes the approaching sound wave, causing the waves to spread apart and interfere with one another. The amount of sound reduced depends upon the barrier's height, width, and type of material.

Carefully angled barrier walls can provide significant attenuation. Reflected sound will come back to the source, but it should be reflected at an indirect angle (see Figure 7-1). The reflected noise has traversed on a lengthened path that causes decreased intensity and loudness. Sound waves end up "somewhere," so you should make sure adverse secondary effects are limited. Recall the example from Chapter 3: a barrier wall was put up to keep base operations noise out, but it amplified street noise and didn't solve the problem!

Sound that is diffracted possesses the same type of sound waves but with diminished intensity than before the barrier was in place. The general procedure for determining the height of a barrier is to determine the length of the diffracted sound path. The difference between the direct and diffracted path is determined, and the associated noise reduction is assigned (see Table 7-10). Note the derivations in Table 7-10 are

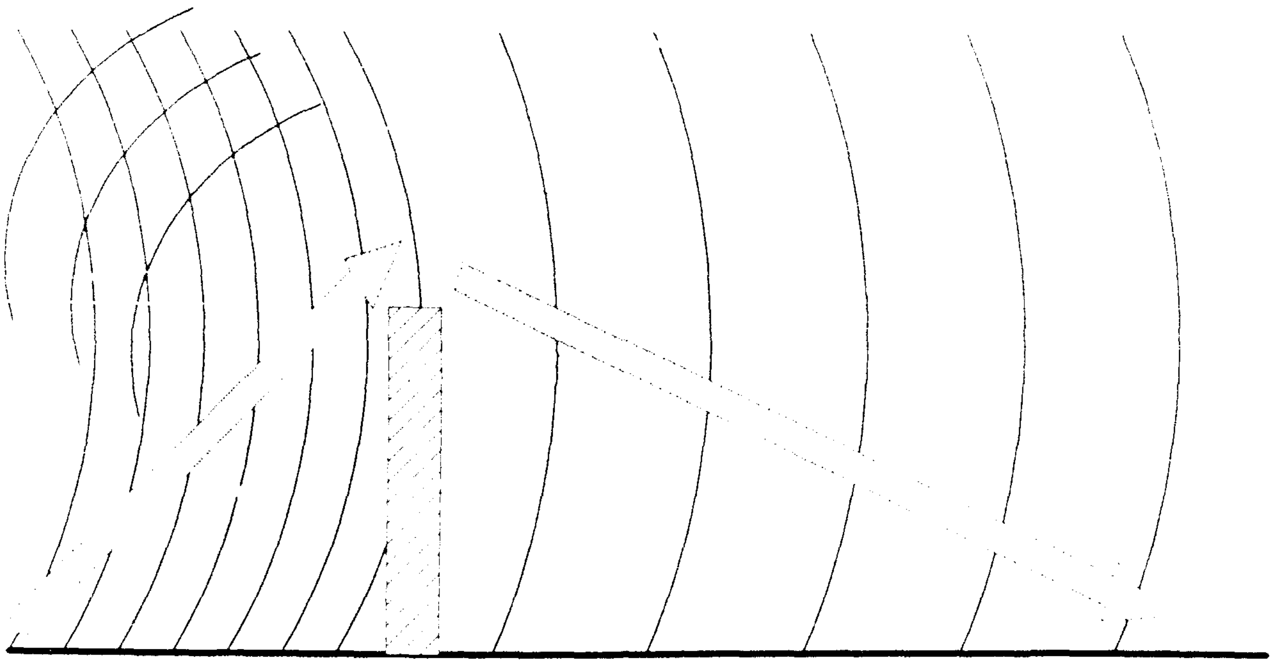

Figure 7-1. Sound Waves Losing Intensity at a Barrier Wall

Barrier Height	Approximate Noise Reduction, Point Source	Approximate Noise Reduction, Line Source
5 ft	11 dB	8 dB
10	16	13
15	18	15
20	21	16
25	23	18
30	24	19
35	24	21

Assumptions:
1) barrier 40 feet from noise source and 150 feet from detector
2) no climatic factors influence the sound in the path
3) sound does not go around the end of the wall
4) source and receiver are at equal elevations
5) barrier height reference point is elevation of source/receiver

Table 7-10. Example of Barrier Height and Effect of Noise Reduction
Source: DOD (1978)

Barrier Type	Potential Noise Reduction (max)	Approxmiate cost 1988 $ per linear foot
Block Wall		
5 feet high	15 dB	7.50 - 16.90
10 feet high	15 dB	15.00 - 33.80
20 feet high	15 dB	30.10 - 69.60
Earth Berm 10 feet high, 10 feet wide, no landscaping	15 dB	22.60
Foliage Strip 100 feet wide	5 dB	74.20

Table 7-11. Barrier Wall Types: Effectiveness and Cost Estimates
Source: DOD (1978)

approximations and possess several assumptions. The type of sound and barrier will affect the amount of attenuation as well. Barriers are only effective for high frequency noise. The wavelengths of low frequency noise are larger and in effect "jump over" barrier walls.

Transmission of noise through the barrier is highly dependent upon the mass of the barrier material. Common types of barrier materials are earthen berms, wood, foliage, concrete, and blocks. Approximate levels of noise reduction and unit costs of selected materials are provided in Table 7-11. More expensive, specially designed noise barrier walls that employ combinations of materials and air space are also available.

The least complicated barriers (and cheapest) are existing buildings. Locating generation-type units on the side of the building opposite noise-sensitive areas can give significant attenuation. Alternative locations will likely exhibit disbenefits, thus careful consideration to the secondary noise impacts of alternative locations should be made.

Strategic placement of generators behind natural barriers such as foliage or slopes can reduce noise. Sandbags have been used successfully as a partial enclosure -- this, of course, requires many sandbags. If earthmoving equipment is available, a notch in a hillside can be used as a partial enclosure as well.

Enclosures can be designed to attenuate noise from generation-type units. These can be very effective but can also be expensive. Noise is reduced just as with barriers except that within the enclosure the reflected and refracted sound waves bounce back and forth protecting the outside environment and virtually eliminating the noise. Vibration from the generation-type unit should not reach the enclosure walls; rubber mounts (as discussed above) aid in separating the vibration. Use of acoustical absorbing material and double walls enhance abatement considerably (see Figure 7-2). It should be noted that enclosures for generator-type units would require airflow hardware which is not shown in Figure 7-2.

Noise Mitigation for Base Operations: Receiver

In a "best case" situation, noise abatement through land use planning and zoning will put the receiver out of range of unwanted

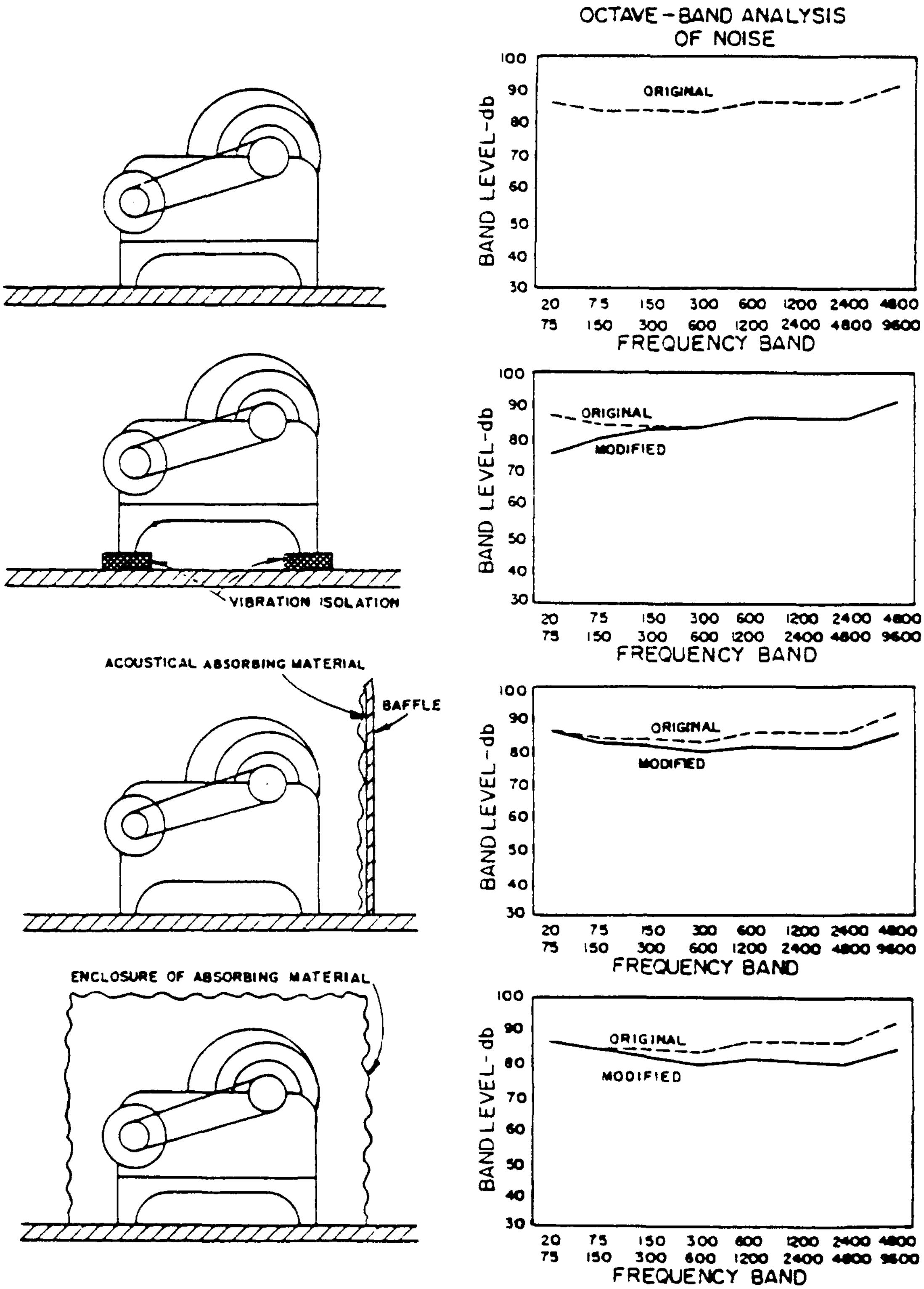

Figure 7-2. Effectiveness of Various Enclosures
Source: EPA (1978)

noise. The reality in Germany is that this approach alone is not sufficient. A number of architectural technologies are available that provide noise protection for those inside the structure (PMCL 1988). Up to 50 dB of noise reduction can be obtained with the proper construction and architectural strategy, although such noise relief will only be experienced by those indoors.

One architectural strategy is to design the garage/storage buildings to be between the living area and the noise source. In the same vein, noise-sensitive rooms (e.g., bedrooms, study) could be placed on the end of the house farthest from the noise source. Horseshoe-shaped houses have been found to weaken noise from many directions (VDI 2718 1975). These types of considerations can be suggested by MILCOMs for newly constructed developments. Not only do suggestions such as these at CRAC meetings reduce noise at some homes, but they also serve as goodwill gestures that demonstrate concern.

Construction techniques can be used to attenuate sound also (see Table 7-12). Some of these techniques can be used after the structure has been built. Noise-proofing inspections or subsidized noise-abatement improvements for nearby structures could be provided. This would be a very practical management option if the number of structures involved is small.

Noise complaints are very seasonal. In cool weather when windows are closed, fewer complaints are made as compared to warm weather seasons when windows are open.

CHAPTER SUMMARY

A wide variety of sound is produced during base operations. Measurements are provided for a variety of generators and vehicles. Noise-mitigation measures for base operations are given below.

* The Army has noise-abatement specialists available at your request.
* You can condense or "trickle" convoy activity to reduce noise impacts.
* Match noisy activities with noisy times of the day and noisy locations.
* Cold weather roll-outs can help reduce noise impacts.

Building Component	Construction Measure
Walls	Increase mass Use "dead" air space Increase airspace width (between walls) Increase airspace length (stud interval) Use staggered studs Seal cracks and edges Use insulation blankets Give special attention to openings; electrical outlets, medicine cabinets, etc. Use resilient materials to hold studs and panels together Use acoustic coating
Roofs	Increase mass Seal cracks and edges
Ceilings	Use insulation blankets Use non-fixed suspension methods Use acoustical coatings
Floors	Increase mass Block off all joists (prevents noise from traveling over and under walls) Use resilient supports between joists and floor
Windows	Use sealed windows Increase glass thickness Use double glazed windows Increase volume of "dead" airspace in double glazed windows
Doors	Use solid core doors Use doorframe gaskets
Interior Design	Use heavy drapes Use heavy carpets Use acoustical ceiling treatment

Table 7-12
Construction Techniques to Minimize Outside Noise
Source: DOD (1978)

* Minimize nighttime activity when possible.
* Avoid high activity during German holidays and celebrations.
* Noise-sensitive housing can reduce indoor noise up to 50dB.
* Use MILCOM structures, such as garages and warehouses, as noise barriers.
* Barriers can be natural or constructed.
* Test vehicles in regular traffic when possible.
* Maximize distance between source and receiver.
* A new line of quiet generators will be out in a couple years.
* Use commercially available power when possible.

ILLUSTRATIVE EXAMPLE: KLEBER KASERNE, KAISERSLAUTERN

The Kleber Kaserne is located in a transition area of Kaiserslautern (Department of Defense, 1986). Around its borders are the Daenner Kaserne, miscellaneous commercial developments, a cemetery, residential areas, and a permanent small-garden facility. The Kaserne is a motor pool facility that maintains and stores military equipment. The motor pool activity associated with the transportation units involves large trucks, and the signal units are made up of mainly generators.

Various noise complaints had surfaced in the past, and various measures to reduce noise impact from the motor pool proper were taken. One measure was training and informing drivers about quiet driving. Horn blowing is a major noise source, and rules and regulations dictating proper horn use were established. When possible, generators were brought toward the Kaserne interior to get noise-reduction benefit from using the buildings as barriers.

Members of the garden facility adjacent to the Kaserne submitted a formal complaint to the mayor of Kaiserslautern about the noise coming from the signal units. The complaint was forwarded to military authorities. After review by Army technical personnel, generator noise was found to be the noise source.

In order to determine the degree of impact the generator noise was creating, background noise calculations were made. Because the nonmilitary background noise was relatively high in the area, the general impact of noise from the motor pool was

minimal. Thus, the highly localized problem of generator noise near the garden. In fact, a single 1.5 kilowatt generator located three meters from the garden perimeter was found to be producing noise levels of 87 dB(A).

Several noise-attenuation measures were developed for the problem area.

(1) A meeting with personnel working in the specific area was held in which the problem was discussed and solutions developed. Communication with the motor pool crew was considered an important step.

(2) Reduce test-run time for generators.

(3) Use commercial power if available and if not restrictive to mission.

(4) Direct generator mufflers away from the garden area. Makeshift muffling devices were recommended by installing a heavy hose connecting the exhaust and a 55 gallon drum.

(5) A green screen was put up between the motor pool and garden. The reduced visibility of the noise source serves as a psychological noise-annoyance reduction measure.

(6) An enclosure, made of lead, vinyl, and fiber glass was designed. Without the enclosure, noise from the generator could be detected at 1,350 meters; with the enclosure, it could not be detected at greater than 400 meters (this is termed effective distance reduction).

Continued communication with the community through CRAC meetings and continued training and information for motor pool personnel ensure minimal noise impact from the Kleber Kaserne.

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CHAPTER 8
TRAINING AREAS

> *Generator units create a continuous "hum"*
> *Weapons firing creates an instant "boom"*
> *Strategic scheduling goes a long way*
> *Keep distance between noise and populace*
> *"Weather" or not to blast*

GENERAL SETTING

This chapter presents noise management ideas and suggestions for training areas. Both local and major training area (LTA/MTA) personnel can reference this chapter, however, the focus is upon LTAs. Firing ranges (small and heavy), tracked vehicles, and mobile generators are the main contributors to noise problems in training areas. Over half the MILCOMs have moderate noise problems with training areas (Dunning and Nolton 1988). Contributing to the noise problems are land use pressure from lands adjacent to the training areas and noise disturbance occurring during night hours and German holidays. Oftentimes, gun clubs (both U.S. and German) cause weekend noise complaints.

PROBLEM DEFINITION

Nature of Training Area Noise

Generators produce a continuous high-frequency tone that is moderately loud (compared to noise from heavy weapons fire). The continuous humming is considered very annoying.

Compared to continuous noise produced by a generator and the noise event produced by a helicopter flyover, weapons firing is a very short, impulse-type noise. Heavy weapons and small arms are both described by impulse noise patterns but are actually quite different. Small arms produce a much higher frequency noise as compared to heavy weapons noise. Tank blast compared to rifle noise is shown in Figure 8-1. The immediate peaks are of similar magnitude, but the wavelength patterns differ substantially. Low-

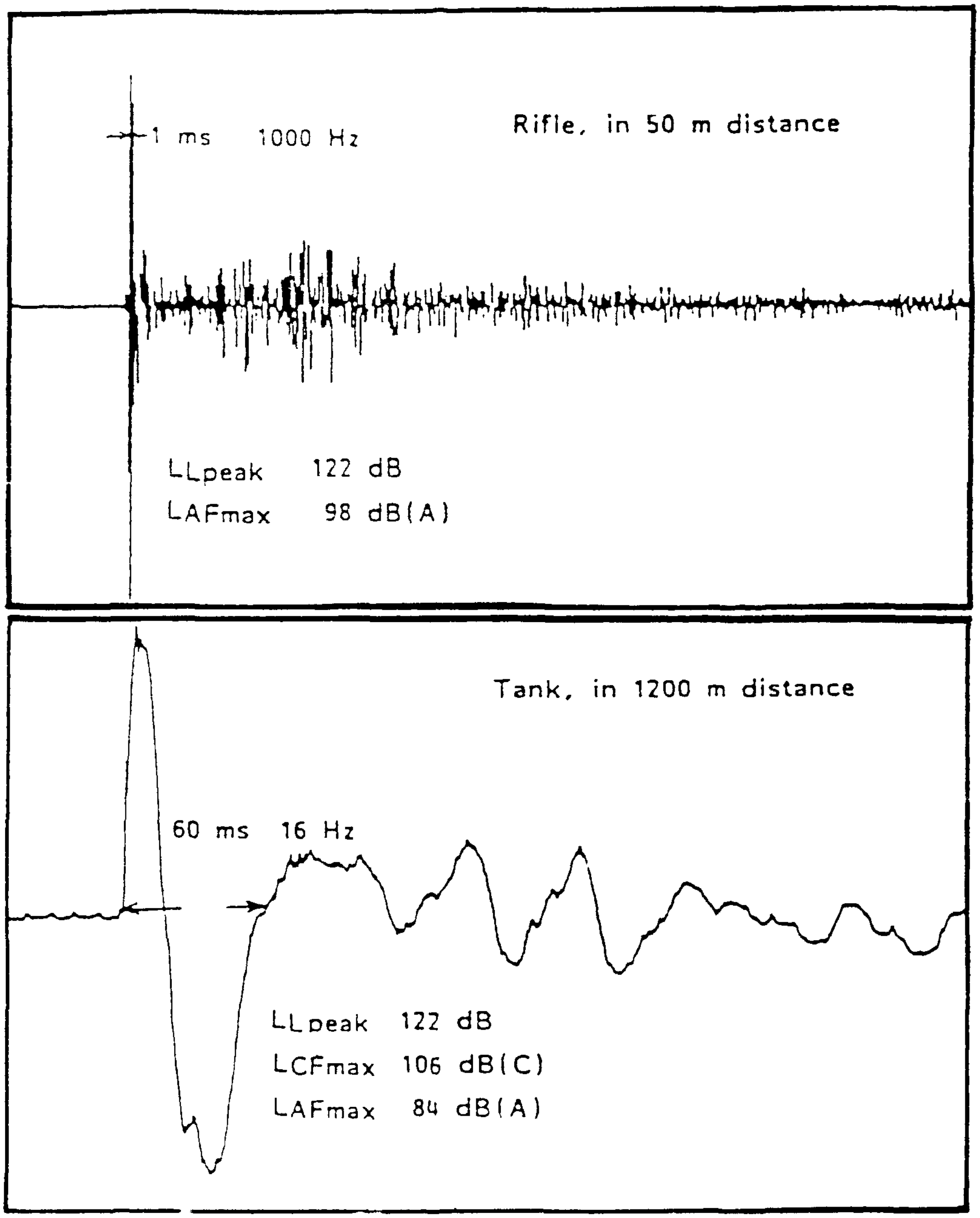

Figure 8-1. Tank and Rifle Sound Waves
Source: PMCL (1988)

frequency noise associated with heavy weapons blasts often produces vibrations that startle people and rattle glass objects and windows in nearby buildings.

Annoyance caused by the heavy-weapons blasts is significantly greater than that caused by small-arms fire. Nearly half of those asked said they found heavy-weapons noise "intolerable," while only 30 percent had similar views of small-arms firing (PMCL 1988).

Training Area Noise Measurements

Development of an effective noise management plan requires an assessment of noise patterns being produced at your installation. A detailed assessment conducted by acoustical experts as identified in Appendix A is highly recommended. They have the tools, computer technology, and expertise needed to provide accurate results.

Assessment Tables

Included in this section are a series of tables that provide noise levels for generators and weapons, and general community annoyance associated with the noise levels. The primary purpose of these tables is to provide you with a general way of assessing the likelihood that noise from activities taking place at your installation may be producing annoyance in the surrounding community. These tables are not a replacement for an actual noise assessment. You can use the tables to get a feel for the level of noise being produced at various distances from the installation. Please understand that the tables were produced under very specific conditions and should serve only as gross approximations to your situation. Proper application of the tables is for low-level judgment such as "Well, I can see why there are so many complaints in that neighborhood"; or "We haven't had problems in the past, but with this increase in activity, maybe we ought to have the acoustical engineers come in to conduct a detailed assessment."

The values in the tables are the LEQ levels produced by a range of operation times at specified distances. Remember from Chapter 2 that LEQ is the average sound level over a specified

period of time, and is therefore relatively insensitive to single events that may cause a particularly high level of annoyance. For example, running a generator for just 15 minutes directly adjacent to a cemetery during a funeral service would be considered highly annoying. But because the generator noise is averaged with other quieter times of the day, the LEQ measure may reveal a less severe noise level. The point here: though LEQ is widely used as a planning tool, blind application can sometimes hide a more severe noise situation.

Noise is noticeable below 50dB (35dB for night) but is typically considered a small problem, thus there is usually a very low occurrence of complaints and annoyance. Between 50dB and 60dB (35dB - 45dB for night) you would expect scattered complaints and annoyance, which are typically considered a moderate problem. This is more of a jump than it appears -- remember a 10dB increase in a single noise event is a perceptual doubling of noise. Substantial problems come about between 61dB and 70dB (46dB - 55dB for night). A very significant portion of the population is annoyed at this range. Anything above 70dB (55dB for night) is considered an immense noise problem and will likely result in vigorous community reaction.

Tables 8-1 through 8-8 illustrate the LEQ levels for a variety of generator sizes. Those generators with very similar output levels were combined in several of the tables. The technical notes concerning the creation of the generator tables are provided in Appendix C. Also in Appendix C are the notes for the creation of Tables 8-9 and 8-10 (Noise from the Point of Fire, and Noise from the Point of Explosion of selected weaponry).

MITIGATION MEASURES AT TRAINING AREAS

This section addresses noise attenuation in subsections directed at source-, path-, and receiver-related measures. Mitigation of generator, small-arms and heavy-weapons noise is covered in each subsection.

LEQ Day (dB)

Hours/Days	Distance from Generator (meters) 50	100	400	800
2	53	47	35	29
4	56	50	38	32
8	59	53	41	35
16	62	56	44	38

LEQ Night (dB)

Hours/Night	Distance from Generator (meters) 50	100	400	800
2	56	50	38	32
4	59	53	41	35
8	62	56	44	38

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 8-1. Noise from 0.5, 1.5, and 3.0 Kilowatt Generators

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	56	50	38	32
4	59	53	41	35
8	62	56	44	38
16	65	59	47	41

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	59	53	41	35
4	62	56	44	38
8	65	59	47	41

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 8-2. Noise from 5.0 (gas and diesel) Kilowatt Generators

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	55	49	37	31
4	58	52	40	34
8	62	55	43	37
16	64	58	46	40

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	58	52	40	34
4	62	55	43	37
8	64	58	46	40

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 8-3. Noise from 10.0 (gas and diesel) Kilowatt Generators

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	56	50	38	32
4	59	53	41	35
8	62	56	44	38
16	65	59	47	41

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	59	53	41	35
4	62	56	44	38
8	65	59	47	41

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 8-4. Noise from 15.0 (housed) and 30.0 (housed) Kilowatt Generators

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	62	56	44	38
4	65	59	47	41
8	68	62	50	44
16	71	65	53	47

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	65	59	47	41
4	68	62	50	44
8	71	65	53	47

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 8-5. Noise from 60.0 (housed) and 72.0 (housed) Kilowatt Generators

LEQ Day (dB)

Hours/Days	Distance from Generator (meters) 50	100	400	800
2	60	54	42	36
4	63	57	45	39
8	66	60	48	42
16	69	63	51	45

LEQ Night (dB)

Hours/Night	Distance from Generator (meters) 50	100	400	800
2	63	57	45	39
4	66	60	48	42
8	69	63	51	45

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 8-6. Noise from a 100.0 (housed) Kilowatt Generator

LEQ Day (dB)

	Distance from Generator (meters)			
Hours/Days	50	100	400	800
2	66	60	48	42
4	69	63	51	45
8	72	66	54	48
16	75	69	57	51

LEQ Night (dB)

	Distance from Generator (meters)			
Hours/Night	50	100	400	800
2	69	63	51	45
4	72	66	54	48
8	75	69	57	51

		Day (dB)	Night (dB)
Small problem		Less than 50	Less than 35
Moderate problem		50 - 60	35 - 45
Substantial problem		61 - 70	46 - 55
Immense problem		71 and above	56 and above

Table 8-7. Noise from a 100.0 (unhoused) Kilowatt Generator

LEQ Day (dB)

Hours/Days	Distance from Generator (meters)			
	50	100	400	800
2	68	62	50	44
4	71	65	53	47
8	74	68	56	50
16	77	71	59	53

LEQ Night (dB)

Hours/Night	Distance from Generator (meters)			
	50	100	400	800
2	71	65	53	47
4	74	68	56	50
8	77	71	59	53

	Day (dB)	Night (dB)
Small problem	Less than 50	Less than 35
Moderate problem	50 - 60	35 - 45
Substantial problem	61 - 70	46 - 55
Immense problem	71 and above	56 and above

Table 8-8. Noise from a 200.0 (housed) Kilowatt Generator

	CSEL Noise Measurements (dB)			
	Distance from Point of Fire (meters)			
Weapon Type	150	300	900	3000
60mm Mortar	86	79	66	53
81mm Mortar	88	80	68	54
107mm Mortar	88	80	66	54
106mm Howitzer (M102)	92	84	71	58
25mm Gun	103	95	82	69
155mm Howitzer (M109A1)	105	97	85	71
155mm Howitzer (M198)	106	98	86	72
203mm Howitzer (M110A1)	104	96	83	68
105mm Tank (sabot)	111	103	91	77
120mm Tank (sabot)	121	113	101	87
152mm Tank	117	109	97	83
TOW	117	109	97	83
LAW	118	110	98	84
MLRS	123	115	102	89
90mm RR	117	109	97	83
106mm RR	119	111	99	85

	CSEL (dB)
Not annoying	55 and below
Slightly annoying	56 - 75
Significantly annoying	76 - 95
Very annoying	96 - 115
Extremely annoying	116 and above

Table 8-9. Noise from the Point of Fire of Selected Weaponry

Noise Source	CSEL Noise Measurements (dB): Distance from Point of Explosion (meters)			
	150	300	900	3000
Grenade Simulator	99	91	78	65
Artillery Simulator	103	95	83	89
Artillery Flash Simulator	102	94	81	88
80mm HE	119	111	99	85
Demolition (1lb)	119	111	99	85
81mm HE	123	115	103	89
107mm HE	127	119	107	93
105mm How HE	125	117	105	91
155mm HE	130	122	109	96
203mm HE	133	125	113	99
165mm HEP for CEV	133	125	113	99

	CSEL (dB)
Not annoying	55 and below
Slightly annoying	56 - 75
Significantly annoying	76 - 95
Very annoying	76 - 115
Extremely annoying	116 and above

Table 8-10. Noise from the Point of Explosion of Selected Weaponry

Planning for a Training Event

Because so many different parties use training areas, communication between LTA Coordinators (LTA-C) and Commanding Officers (CO) on the issue of noise should be formalized. COs need to be as noise conscious as the LTA-C. The decision flowchart shown in Figure 8-2 describes a general process that promotes noise consciousness during the training exercise preparation/planning and coordination.

The next few paragraphs explain the flowchart in Figure 8-2; if you follow through you'll see that most of it is common sense and communication. This process may seem cumbersome, but as you start to get a feel for noise levels associated with certain activities, it will become streamlined. You may want to take creative privilege to adapt the process to the actual paper shuffle that takes place at your LTA.

A unit is preparing for activities which require use of the LTA. The CO submits a request to the LTA-C listing the training activity and number of soldiers. The LTA-C receives the request and returns a packet to the CO that contains pertinent noise information such as the tables in this manual, SOP, and/or any other pertinent maps or information regarding noise at the LTA.

The CO estimates noise created from the requested training activity and compares it to the noise information sent by the LTA-C. This handbook serves as a good first approximation for noise planning needs. The CO can call upon the LTA-C for specific questions and can get technical assistance of DEH. If it appears that the training activity will cause a noise problem, the CO must determine whether the activity is essential. If the noise can be quieted by altering the training activity without harming the training mission, then all is fine.

In some cases the training activity will be deemed necessary, thus further regulatory action must be taken. A memo explaining the necessary training situation should go to the MILCOM noise management committee (consisting of LTA-C, PAO, Installation Coordinator, DEH representative). The memo should contain at minimum: a copy of the original training request submitted to the LTA-C; a necessity of the training mission being carried out in the

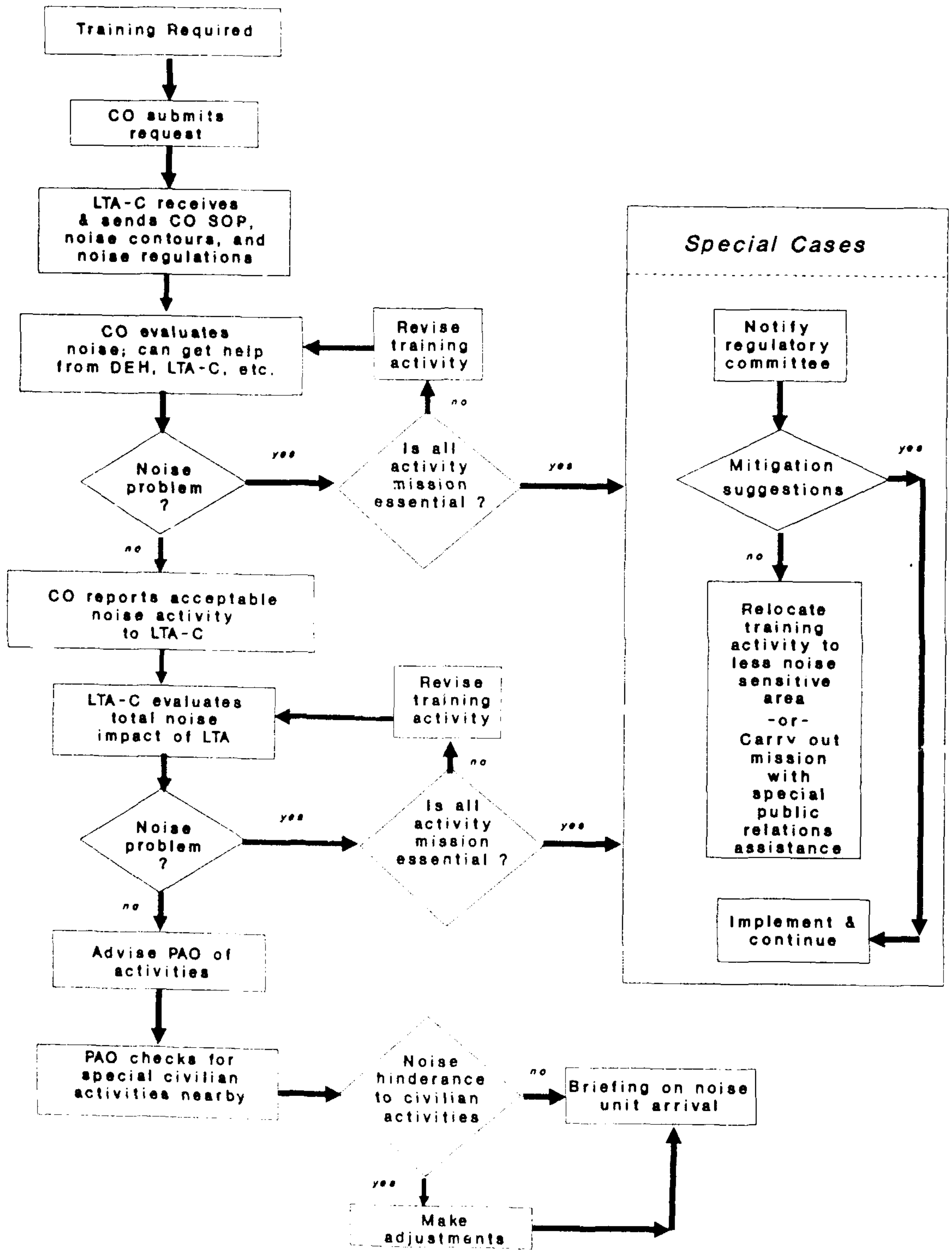

Figure 8-2. Planning for Noise at the LTA

requested fashion. The committee will be able to make suggestions to quiet the problem.

In the case where all quieting options are unacceptable and the noisy activity is required, the committee has two options. The first is to request the activity take place at an LTA that is situated in a less noise-sensitive area. The second option is to approve the activity but issue proper warnings to the community and/or implement other public relations actions that will lessen the intensity of the noise problem (see Chapter 4).

Chances are the memo process won't have to be carried out, because the COs noise evaluation will show no problems, or training adjustment will quiet things down. In this case, the CO resubmits the training request, which has been found to be within noise regulations. The LTA-C must now determine what the total noise impact of the LTA is going to be. For example, this request may be for rifle range certification, but the other part of the LTA may be used for mortar firing. It is the LTA-C's job to make sure the aggregate noise level will not present noise problems. The same quieting procedure as the CO went through should be undertaken if aggregate noise levels are too loud. The LTA has the added option of staggering the schedules so that two "noisy" activities don't combine to cause problems.

After the LTA-C determines the acceptable aggregate noise level, the training activity will have passed two noise filters: one for the individual training activity and another as part of the aggregate noise activity of the LTA. One more filter should be passed. The LTA-C should provide activity reports to the PAO on a weekly basis. The report should contain the dates and times of all scheduled activities and associated noise impacts. The PAO, who will be abreast of social activities and special events happening in the nearby communities, will convey this information to the LTA-C. If for example, a funeral is scheduled in a cemetery near a certain target area, the PAO will inform the LTA-C of this, and appropriate adjustments should be made. This final filter is very important. A weak link between the PAO and LTA-C will negate all mitigatory-planning efforts to this point.

When the unit arrives at the training area, a briefing session should take place. The entire unit, LTA-C, and PAO should be in attendance. Noise-abatement procedures should be presented including those both stated in the SOP and any special measures taken for the particular training event. This time should be used

to clear up any questions the visiting unit may have regarding outline of the specific noise problem; and justification for the noise.

This type of communication and filtering process is essential to noise management at the LTA. Paper shuffling and communication processes may already exist at your LTA. If so, check to see that noise is being addressed in a similar fashion to that presented in Figure 8-2.

Mitigation Tips

The planning framework presented above referenced adjustments to quiet the noise coming from the LTA. This section provides measures for quieting LTA noise at the source.

Probably the most accessible noise-mitigation measure for the training area is planning at the source (see above discussion). Operation hours can be set that limit noise exposure during German holidays and sleeping hours. Scheduling louder activities during noisier times of the day lessens the noise impact of the activity because it blends in with background noises of the city.

Keeping abreast of local events helps to ensure minimal interference. Noise-sensitive operation schedules included in the SOP provide an instrument for which the many parties using the area can remain informed of permitted operating times. Distinguishing quiet hours in the SOP also serves as a demonstration of official action toward noise management. The benefits of this can go a long way with nearby villages and towns (see Chapter 4 for expansion of this notion).

Space between the noise source and sensitive areas should be maximized. Each doubling of distance reduces loudness approximately 6 dB. Scheduling the loudest and/or most frequent activities toward the maximum "separation point" and then gradually working toward more sensitive areas ensure maximum distance and "free" noise attenuation. Training areas situated in the middle of a populated area would start from the middle of the training area and move out.

Generator Noise

There are commercially available generators that are quieter than many of those the Army presently uses. Any efforts in this direction, whether approved or not, should be advertised to the German public. The mere gesture of looking into something like this often "quiets" the situation (again, see Chapter 4 for further public affairs approaches).

The feasibility of introducing quieter generators is presently being examined. The Army's Logistic Equipment Directorate, Power Generation Division, has been researching generator noise intensely. They have made significant progress and expect to replace a majority of the existing "loud" generators with units that produce a much lower level of noise (70 dB(A) or less at 25').

Small Weapons Firing

Small-arms weapons have very few source-related abatement options. Gun silencers or suppressors have been examined in laboratories, but actual use is very limited (Goff and Novak 1977, Dunning and Nolton 1988), though a system providing 10-15 dB (A) has been developed (Buchta 1988).

Heavy Weapons Firing

Heavy-weapons firing under a few prescribed conditions can provide significant noise reduction. Noise occurs at both the firing point and the target, thus distance between the populace and the blast should be maximized. Sound level directly behind the firing point is much lower than the sound in front of it, therefore shooting directly away from noise-sensitive areas limits the noise impact.

Smaller charges can often be used with very little hindrance to the mission. In general, halving the explosive charge decreases loudness by 3 dB. As weight of the charge increases, loudness increases, as does annoyance from low-frequency vibration (PMCL 1988).

High-explosive rounds (HE) are the loudest option you have for training. The blast noise tables presented earlier in this chapter were HE rounds. Quieter rounds such as training, illumination, smoke, LITR, and white phosphorous can be used to eliminate much of the noise from the blasting activity. Remember though, in many cases you still have propellant noise to deal with.

Explosions planned for swampy areas will stifle blast noise. Specially designed trenches with synthetic foam may also absorb some of the blast noise (PMCL 1988). The use of VT versus PT fuses allows the timing of a blast to be specified. Proper setting of the VT fuse permits burial of the charge, which muffles the blast considerably. The amount of attenuation depends on the type of explosive, the weight, and the depth of burial. Examples of noise attenuation from buried charges are shown in Table 8-11.

Noise Mitigation at Training Areas: Path

Barriers are the most common approach to abating base-operation-related noise at the path. Generators and refrigeration-type units (referred to now simply as generation-type units) produce distinctive, relatively high-frequency "humming" noise that can readily be attenuated by barrier walls or enclosures. It should be noted that barriers don't work to abate noise caused by heavy weapons.

Sometimes a situation will call for the construction of an actual noise attenuation barrier. The expertise of acoustical engineers identified in Appendix A is required in this instance. Many MILCOMs have constructed noise barrier walls and received security as well as noise-attenuation benefits. Presenting multipurpose objectives can strengthen the justification for the construction of a barrier wall. Other aspects of a barrier to consider are maintenance, aesthetics, and safety.

Barriers located in the line of sight of the source and receiver transmit, reflect, and diffract sound waves (see Figure 8-3). The barrier wall impedes the approaching sound wave, causing the waves to spread apart and interfere with one another. The amount of sound reduced depends upon the barrier's height, width, and type of material.

Carefully angled barrier walls can provide significant attenuation. Reflected sound will come back to the source, but it

Explosive Type	Depth of Charge, meters						
	0.2	0.4	0.6	0.8	1.0	1.2	1.4
		(noise reduction, dB)					
TNT	6.4	9.9	13.3	16.7	20.2	23.7	27.1
Tetrytol, M1, M2	6.2	9.5	12.7	15.9	19.2	22.4	25.7
Compos'n C3, M3, M5	6.1	9.2	12.3	15.4	18.6	21.7	24.8
Compos'n C4,M4A1,M112	6.1	9.2	12.3	15.4	18.6	21.7	24.9
Ammonium Nitrate	7.6	12.1	16.7	21.3	26.0	30.6	35.2
M1	6.5	10.0	13.6	17.1	20.7	24.2	27.8
PETN	5.9	8.8	11.7	14.6	17.5	20.4	23.4
Tetryl	6.2	9.4	12.5	15.7	19.0	22.2	25.4
Composition B	6.1	9.2	12.3	15.4	18.6	21.7	24.8
Amatol 80/20	6.3	9.5	12.8	16.0	19.3	22.6	25.9
Black Powder	7.2	11.4	15.6	19.8	24.0	28.2	32.4

Based upon an 8 kg charge

Table 8-11
Effects of Charge Burial

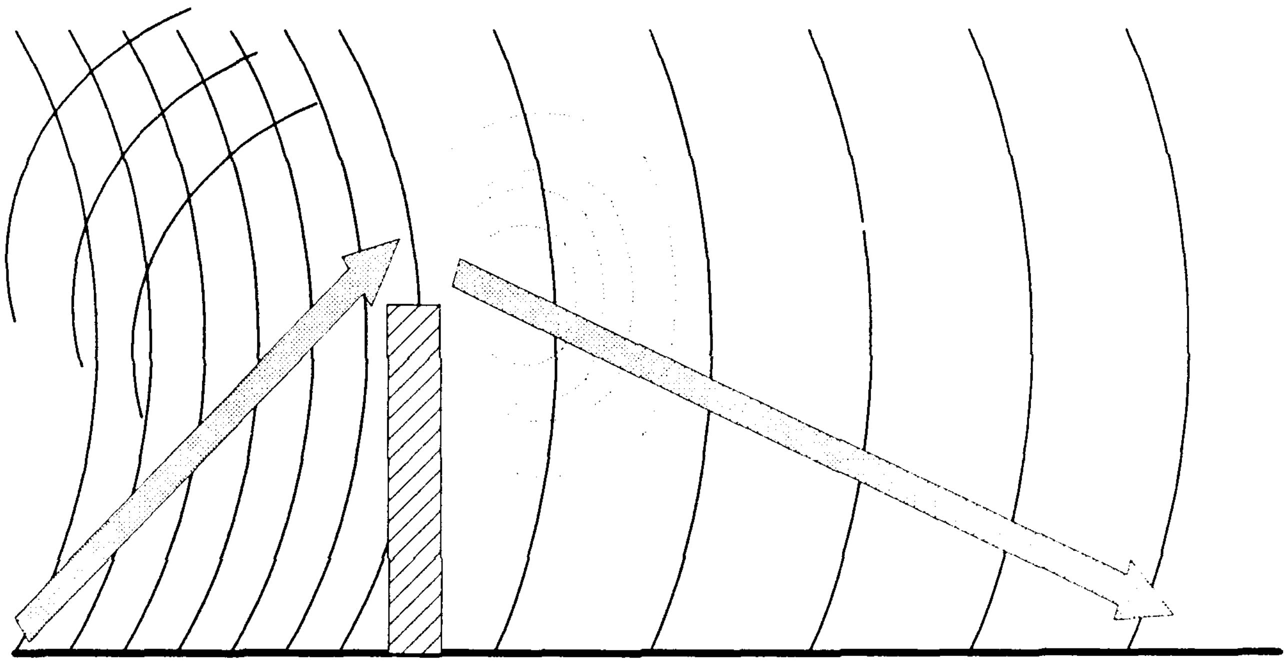

Figure 8-3. Soundwaves Losing Intensity

should be reflected at an indirect angle (see Figure 8-3). The reflected noise has traversed on a lengthened path that causes decreased intensity and loudness. Sound waves end up "somewhere," so you should make sure adverse secondary effects are limited. Recall the example from Chapter 3: a barrier wall was put up to keep base operations noise out, but it amplified street noise and didn't solve the problem!

Sound that is diffracted possesses the same type of sound waves but with diminished intensity than before the barrier was put in place. The general procedure for determining the height of a barrier is to determine the length of the diffracted sound path. The difference between the direct and diffracted path is determined, and the associated noise reduction is assigned (see Table 8-12). The type of sound and barrier will affect the amount of attenuation as well. Note the derivations in Table 8-12 are approximations and possess several assumptions. Barriers are only effective for high frequency noise. The wavelengths of low frequency noise are larger and in effect "jump over" barrier walls.

Transmission of noise through the barrier is highly dependent upon the mass of the barrier material. Common types of barrier materials are earthen berms, wood, foliage, concrete, and blocks. Approximate levels of noise reduction and unit costs of selected materials are provided in Table 8-13. More expensive, specially designed noise barrier walls that employ combinations of materials and air space are also available.

The least complicated barriers (and cheapest) are existing buildings. Locating generation-type units on the side of the building opposite noise-sensitive areas can give significant attenuation. Alternative locations will likely exhibit disbenefits, thus careful consideration to the secondary noise impacts of alternative locations should be made.

Strategic placement of generators behind natural barriers such as foliage or slopes can reduce noise. Sandbags have been used successfully as a partial enclosure -- this, of course, requires many sandbags. If earthmoving equipment is available, a notch in a hillside can be used as a partial enclosure as well.

Enclosures can be designed to attenuate noise from generation-type units. These can be very effective but can also be expensive. Noise is reduced just as with barriers except that within the enclosure the reflected and refracted sound waves bounce back and forth protecting the outside environment and virtually

Barrier Height	Approximate Noise Reduction, Point Source	Approximate Noise Reduction, Line Source
5 ft	11 dB	8 dB
10	16	13
15	18	15
20	21	16
25	23	18
30	24	19
35	24	21

Assumptions:
1) barrier 40 feet from noise source and 150 feet from detector
2) no climatic factors influence the sound in the path
3) sound does not go around the end of the wall
4) source and receiver are at equal elevations
5) barrier height reference point is elevation of source/receiver

Table 8-12. Example of Barrier Height and Effect of Noise Reduction.
Source: DOD (1978)

Barrier Type	Potential Noise Reduction (max)	Approxmiate cost 1988 $ per linear foot
Block Wall		
5 feet high	15 dB	7.50 - 16.90
10 feet high	15 dB	15.00 - 33.80
20 feet high	15 dB	30.10 - 69.60
Earth Berm 10 feet high, 10 feet wide, no landscaping	15 dB	22.60
Foliage Strip 100 feet wide	5 dB	74.20

Table 8-13. Barrier Wall Types: Effectiveness and Cost Estimates.
Source: DOD (1978)

eliminating the noise. Vibration from the generation-type unit should not reach the enclosure walls; rubber mounts (as discussed above) aid in separating the vibration. Use of acoustical absorbing material and double walls enhance abatement considerably (see Figure 8-4). It should be noted that enclosures for generator-type units would require airflow hardware which is not show in Figure 8-4.

A coffered ceiling used at firing ranges in Germany has reduced noise up to 15 dB (PMCL 1988). The ceiling allows air and light to pass, but limits noise exposure. The firing ranges that have had this type of ceiling installed have experienced great noise-reduction success, and complaints have been reduced to nearly none. These ceilings are being considered for 22 of the 220 existing rifle ranges in Germany at a cost of about 400 DM per square meter (in 1988).

Air temperature, temperature gradient, and wind direction significantly affect the travel of impulse noise. Flexibility to allow for unpredictable climatic conditions should be maintained. "Good" and "bad" conditions for firing are shown in Table 8-14.

Sound moves more quickly in higher temperatures. Normal temperature gradients tend to decrease with altitude. Consequently, under normal temperature gradient conditions, sound waves bend upward away from the ground/population. Attention to the temperature gradient, which peaks near noontime, can provide significant attenuation. When an inverse gradient exists (temperatures increasing with altitude) very adverse noise conditions occur on the ground.

Sound also moves in the direction of the wind. Consequently, high-noise activity should be kept downwind of noise-sensitive areas. Particular attention to daily wind patterns by season can allow planning of blast drills.

Noise Mitigation at Training Areas: Receiver

In a "best case" situation, noise abatement through land use planning and zoning will put the receiver out of range of unwanted noise. The reality in Germany is that this approach alone is not sufficient. A number of architectural technologies are available that provide noise protection for those inside the structure (PMCL 1988). Up to 50 dB of noise reduction can be obtained with the

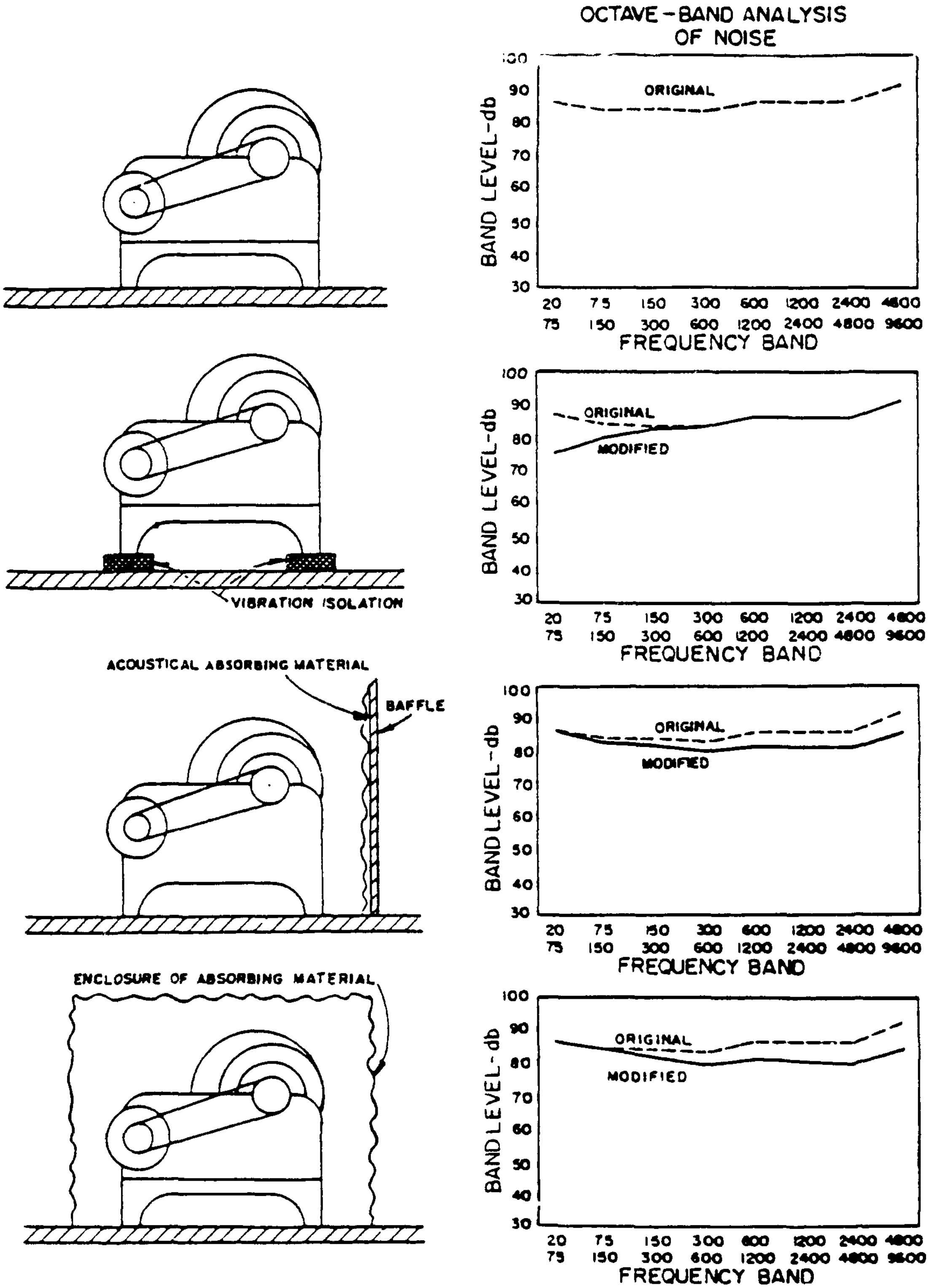

Figure 8-4. Effectiveness of Various Enclosures
Source: EPA (1978)

Good Firing Conditions	Bad Firing Conditions
Clear skies with billowy cloud formations, especially during warm periods of the year	Days of steady winds 10-15 mph with gusts of greater velocities (20 mph or more) in direction of residence close by
A rising barometer immediately following a storm	Clear days on which layering of smoke or fog is observed
	Cold, hazy or foggy mornings
	Days following a day when large extremes of temperature (about 20 degrees C) between day or night were noted
	Generally high barometer readings with low temperatures

Table 8-14
Good and Bad Weather Conditions for Firing Heavy Weapons
Source: Raspet and Novak (1988)

proper construction and architectural strategy, although such noise relief will only be experienced by those indoors.

One architectural strategy is to design the garage/storage building to be between the living area and noise source. In the same vein, noise-sensitive rooms (e.g., bedrooms, study) could be placed on the end of the house farthest from the noise source. Horseshoe-shaped houses have been found to weaken noise from many directions (VDI 2718 1975). These types of considerations can be suggested by MILCOMs for newly constructed developments. Not only do suggestions such as these at CRAC meetings reduce noise at some homes, but they also serve as goodwill gestures that demonstrate concern.

Construction techniques can be used to attenuate sound also (see Table 8-15). Some of these techniques can be used after the structure has been built. Noise-proofing with the proper construction and architectural strategy could be provided, although such noise relief will only be experienced by those indoors. This would be a very practical management option if the number of structures involved is small.

Noise complaints are very seasonal. In cool weather when windows are closed, fewer complaints are made as compared to warm weather seasons when windows are open. This should certainly be noted if subsidizing soundproof windows is being considered, because the resultant attenuation will likely be seasonal as well!

CHAPTER SUMMARY

Noise mitigation at training areas requires a certain level of noise consciousness of both the training area and unit personnel. Estimation of noise impacts of training before the activity takes place is crucial. Here are measures that can be taken to reduce training area noise:

* The Army has noise-abatement specialists available at your request.
* Match noisy activities with noisy times of the day and noisy locations.
* Minimize nighttime activity when possible.
* Avoid high activity during German holidays and celebrations.
* Noise-sensitive housing can reduce indoor noise up to 50 dB.
* Use MILCOM structures, such as garages and warehouses, as noise barriers.
* Barriers can be natural or constructed.
* Test vehicles in regular traffic when possible.
* Maximize distance between source and receiver.
* A new line of quiet generators will be out in a couple years.

Building Component	Construction Measure
Walls	Increase mass Use "dead" air space Increase airspace width (between walls) Increase airspace length (stud interval) Use staggered studs Seal cracks and edges Use insulation blankets Give special attention to openings: electrical outlets, medicine cabinets, etc. Use resilient materials to hold studs and panels together Use acoustic coating
Roofs	Increase mass Seal cracks and edges
Ceilings	Use insulation blankets Use non-fixed suspension methods Use acoustical coatings
Floors	Increase mass Block off all joists (prevents noise from traveling over and under walls) Use resilient supports between joists and floor
Windows	Use sealed windows Increase glass thickness Use double glazed windows Increase volume of "dead" airspace in double glazed windows
Doors	Use solid core doors Use doorframe gaskets
Interior Design	Use heavy drapes Use heavy carpets Use acoustical ceiling treatment

Table 8-15
Construction Techniques to Minimize Outside Noise
Source: DOD (1978)

ILLUSTRATIVE EXAMPLE: FERRIS BARRACKS, ERLANGEN

A tank crew proficiency course is operated at Ferris Barracks. The barracks course is adjacent to a middle school and a university. Firing does not take place at the course, the noise produced is vehicle noise.

The addition of concrete turnpads and firing points to the course caught the attention of city officials as this would increase the noise from the course significantly. Proximity to the two schools was a major concern. The concern was made known to the Army, and a study was carried out (DOD 1989).

In order to define the problem empirically, background noise measurements were made. With street traffic and other "city sounds" the background noise was approximately 46 dB(A). With the tank maneuvers, the noise levels were pushed up to average daily noise levels of about 62 dB(A). Because this area was considered exclusively residential by the city of Erlangen, the noise levels from the course exceeded the regulatory standard (50 dB(A) day, 35 dB(A) night). The ironic twist in this situation is that daytime noise is the issue because of annoyance while school is in session.

The tank course upgrade was designed to have a 10 meter berm barrier wall protecting three of its four sides. The analysis showed that this would be more than enough to mitigate the noise, in fact it was recommended that the berm only be built 5 meters high to provide sufficient noise protection.

Annoyance at the schools was the main concern, so efforts were made to schedule more heavily during non-school hours. The only other area of concern was a residential area, but it was too far away to be affected.

As of this writing, we don't know the effectiveness of the berm. Benefits of the analysis were certainly received. First, good relations were maintained with the city. Efforts were made to manage noise "proactively" rather than "reactively." Also, the added benefits were realized in the form of reduced construction cost because of the scaled-down berm.

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CHAPTER 9
HOUSING AND RECREATION AREAS

Take leisure-related noise seriously
Enforce quiet hours
Leisure noise mitigation is a great secondary benefit
Creative cadence calling calms conflict
Let your neighbors play too

GENERAL SETTING

Noise originating from housing and recreational areas is covered in this chapter. Social activities stemming from nightclubs, parties, etc., and cadence calls are the main sources of annoyance. About 23 percent of the MILCOMs felt these types of noises were at least of moderate concern (Dunning and Nolton 1988).

PROBLEM DEFINITION

The first step in defining housing- and recreation-related problems is to take it seriously. People who are against something will look for any reason to discredit it. For example, if a citizens group is building up resistance to Army maneuvers at a particular area, they will use any reason to cast negative light on the Army -- including loud soldiers. This is a problem that needs to be dealt with.

Another reason to take housing/recreation noise seriously is that the Germans complain about it. One MILCOM reported the following annual noise complaint list:

Motor pool-related complaints	-	6
Aircraft-related complaints	-	3
Drunk soldiers	-	12
Cadence calling	-	18

Recreation- and housing-related noise problems are real and should be taken seriously.

Handling this type of noise may be the most difficult of all the military-related noise problems because of the difference in cultures between the Americans and Germans. Culture and life-styles are impossible to mitigate. American soldiers stationed in Germany are of an "active age," many are away from home for the first time and are "cutting loose." This is by no means a justification for the noise, but it is the root of the "boom box and partying soldier" problem.

Cadence calling is another source of complaints. It is in the Army tradition that this take place. It promotes teamwork and camaraderie among the soldiers. As with most of these types of complaints, they are most annoying during quiet hours and German holidays.

Another source of complaint comes from athletic events such as softball, football, and basketball games. Loud voices, cheering, etc., at the wrong time of the day (or night) are considered annoying in some instances.

No measurements of recreation- and housing-related noise are provided. You have probably heard a loud stereo before or cheering at a softball game. The level of noise is not really that important, because the abatement measures are mainly elimination rather than quieting.

MITIGATION MEASURES FOR HOUSING AND RECREATION AREAS

Noise Mitigation for Housing and Recreation Areas: Source

Mitigation at the source is the main mode of noise abatement for housing and recreation noise. Scheduling and common sense at the source is the main approach to noise abatement. If a barracks barbeque or a softball game or cadence calling is planned, make sure it will not disturb the German public. Check with the PAO to make sure the recreational activity won't disrupt special events taking place in the community.

The source of many noise problems is not planned activities but individuals and small parties. The most common approach for

loud music-related noise is to place quiet hours in the SOP. An example SOP aimed at noise says:

> Amplified noise/music transmitted from either a public building, private residence, or motor vehicle will not exceed a volume that can barely be heard from 20 feet away.
>
> Musical instruments may be played in quarters between 0800 and 1900 hours, Monday through Friday, and 1000 to 1900 hours, Saturday, Sunday and holidays. At no time will the volume be so loud or annoying as to disturb occupants of adjacent apartments. Additionally, the residential noise disturbance ban between 1300 and 1500 daily will be observed.

Enforcement rules are also commonly used and are effective. For example, a violator gets a warning for the first offense, the instrument/stereo is confiscated for a week for the second offense, and the third offense results in the instrument/stereo being confiscated for the violator's term at that MILCOM.

Cadence calls must be modified (possibly eliminated) in noise-sensitive areas -- especially during quiet hours and German holidays. Cadence calls employing a quieter form of group syncopation could be used such as a whispered chant or snapping fingers. This may sound ridiculous, but traditional cadence calling cannot take place in residential areas if you want to maintain good public relations. While marching through residential areas, a single caller could shout cadence, thus keeping the rhythm but at a quieter level. Some cadence calls include offensive language -- these should be reserved for secluded areas.

Locating recreation fields can be tricky. In one case, they serve as a good buffer zone between residential areas and regular military activities (i.e., motor pool activity). On the other hand, if the softball diamond, for instance, is right next to a residential area, game times will be especially loud. Try to keep recreation fields away from noise-sensitive areas if they aren't acting as buffer zones.

Noise Mitigation at Housing and Recreation Areas: Path

Keeping windows closed while loud music is playing will provide significant attenuation. If it is summertime, it may be hot

without ventilation provided by open windows. In this case, the event could be held in an air-conditioned facility.

Barriers designed to explicitly mitigate recreational activities, such as loud music from barracks, would probably be difficult to justify. If other noises from the MILCOM needed to be mitigated via a barrier wall, then music-related abatement could serve as a secondary benefit. In some cases, a barrier wall around housing areas can be justified by keeping street noise out of the housing area. In this case, a dual purpose would be served. Barriers walls also provide security. Further discussion of barrier walls is provided in Chapters 7 and 8.

Try to schedule activities as far from noise-sensitive areas as possible. Remember each doubling of distance provided between the source and receiver reduces the noise by about 6 dB. If a building is between the source and receiver, further attenuation is received.

Noise Mitigation at Housing and Recreation Areas: Receiver

Special low-noise construction features for nearby residents would be difficult to justify as a measure to abate housing- and recreation-type noise. If you suggest to residents that they install special double windows so the soldiers can play their boom boxes, that will probably not go over too well. As with the barrier walls, recreation/housing noise as the secondary source of noise to be attacked would be much easier to justify. For example, if the Army was considering the purchase of special windows for the church across from the street from the signal unit, secondary benefits from housing/recreation noise reduction would be realized. These secondary benefits could help justify the noise-abatement windows. Further discussion of special low-noise construction measures are covered in Chapters 7 and 8.

In terms of recreational noise from athletic events, one approach may be to get the "receiver" involved. See if nearby communities would like to take part in the athletic events. This would improve public relations and seemingly reduce the annoyance of athletic events, because Germans are involved.

CHAPTER SUMMARY

Recreation/housing-related noise is something that should be taken seriously. In some respects, it is the most difficult to deal with because it is the result of a life-styles clash between young Americans and Germans. Noise-abatement measures that can be taken are as follows:

* Place quiet hours and noise restrictions in SOPs.
* Group recreation events should not disturb community special events.
* Limit cadence calls in residential areas.
* Maximize distance between source and receiver.
* Housing/recreation noise abatement is a great secondary benefit.
* Get the local community involved in athletic events.

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APPENDIX A

ACOUSTICAL EXPERTS

U.S. Army 10th Medical Laboratory
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06371-868558

U.S. Army Corps of Engineers
Construction Engineering
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U.S. Army Environmental Hygiene Agency
ATTN: HSHB-CP
Aberdeen Proving Ground, MD 21010-5422
(301) 671-3797

Corps of Engineers European District
APO NY 09757-5301
06101-84495

APPENDIX B

Equation for Wavelength

$$W = c/f$$

where: W = wavelength, feet
c = speed of sound, feet/second
f = number of cycles per second, hertz

Equation for Sound Pressure Level

$$SPL = 10 \log(p/p_o)^2$$

where: SPL = sound pressure level, dB
p = sound pressure of the acoustical signal above atmospheric pressure
p_o = reference pressure, 20 microposcals

Summation of Two Sound Pressure Levels

Given: SPL_a = 60 dbB;
SPL_b = 50 dB
p_o = 20

Find: SPL_{TTL}

where:
$$\begin{aligned} SPL_{TTL} &= SPL_a + SPL_b \\ &= 10 \log(p_a/p_o)^2 + 10 \log(p_b/p_o)^2 \\ &= 10 \log[(p_a/p_o)^2 + (p_b/p_o)^2] \end{aligned}$$

Solve for p_a and p_b ...

$$\begin{aligned} 60 &= 10 \log(p_a/p_o)^2 \\ 6 &= \log(p_a)^2 - \log(p_o)^2 \\ 6 &= \log(p_a)^2 - \log(20)^2 \\ 6 &= \log(p_a)^2 - 2.602 \end{aligned}$$

$$\begin{aligned} \log(p_a)^2 &= 8.602 \\ \log(p_a) &= 4.301 \\ p_a &= 19{,}999 \text{ pa} \\ p_b &= 6{,}324 \text{ pa (using the same algebra)} \end{aligned}$$

Plug p_a and p_b into SPL_{TTL} equation ...

$$\begin{aligned} SPL_{TTL} &= 10 \log\left[\left(\frac{19{,}999}{20}\right)^2 + \left(\frac{6{,}324}{20}\right)^2\right] \\ &= \underline{\underline{60.4 \text{ dB}}} \end{aligned}$$

Schultz Curve Equation

$$PHA = 0.8553(DNL) - 0.401\ (DNL)^2 + 0.00047\ (DNL)^3$$

where: PHA = percent of population highly annoyed
DNL = day night level, dB

Calculation of Helicopter Noise

Given: Helicopter type = CH-47
SEL(A) = 100 dB, flyover at 150 meters AGL
Flights = 50 daytime flights

Find: L_{eq}(day)

Solution: $L_{eq}(day) = SEL(A) + 10[\log(n_d)] - 47.6$

where: L_{eq}(day) = sound level, dB
SEL(A) = maximum a-weighted sound exposure level, dB
n_d = number of day flights
$L_{eq}(day) = 100 + 10[\log(50)] - 47.6$
$= \underline{69.4\ dB}$

Calculation of Generator Noise

Given: Generator type = 5 KW
SEL(A) = 82 dB @ 25 feet
Running time = 2 hours
Listener distance = 50 meters

Find: L_{eq}(day)

Solution: $L_{eq}(day) = [SEL(A) - 0.4343 * 20 * LN(x/7.62)] + [4.343 * LN(d/16)]$
where: L_{eq}(day) = sound level, dB
SEL(A) = maximum a-weighted sound exposure level @ 25 feet, dB
d = day time duration of noise, hours
x = listener distance, meters
$L_{eq}(day) = [82 - 0.4343 * 20 * LN\ (50/7.62)] + [4.343 * LN\ (2/16)]$
$= \underline{56.6\ dB}$

Calculation of Motor Pool Noise

Given: SEL(A) = 81 dB @ 25 feet
Running time=4 hours nighttime
Listener distance=100 meters

Find: L_{eq}(night)

Solution: $L_{eq}(night) = [SEL(A) - 0.4343 * 20 * LN(x/7.62)] + [4.343 * LN(d/8)]$

where:

L_{eq}(night) = sound level, dB
SEL(A) = maximum a-weighted sound exposure level @ 25 feet, dB
d = night time duration of noise, hours
x = listener distance, meters

$L_{eq}(night) = [81 - 0.4343 * 20 * LN(100/7.62)] + [4.343 * LN(4/8)]$
$= \underline{\underline{55.6\ dB}}$

APPENDIX C

A. AIRCRAFT TABLES, TECHNICAL NOTES

1. SEL(A) data came from NOISESLICE 90.

2. Assumptions:

   a. Single point cut off.
   b. Aircraft flying directly overhead.
   c. All background noise sources are excluded.
   d. Each flyover equals one aircraft.

B. WEAPONS TABLES, TECHNICAL NOTES

1. CSEL data came from NOISESLICE 90.

2. Assumptions:

   a. Smallest propellant weight selected (when applicable).
   b. Firing point measurements are directly behind the firing point (180 degrees).
   c. All background noise sources are excluded.

C. GENERATOR TABLES, TECHNICAL NOTES

1. SEL(A) data came from U.S. Army Logistic Equipment Directorate, Power Generation Division, telephone conservation.

2. Algorithm for calculation of L_{eq} came from NOISESLICE 90.

3. Average of the identified generators of each table were use. The maximum range was 3dB(A).

4. All background noise sources are assumed excluded.

D. MOTOR POOL TABLE, TECHNICAL NOTES

1. SEL(A) data from <u>Quantifying Environmental Noise through Automated Monitoring Case Studies for U.S. MILCOM Mannheim</u>. U.S. Army Environmental Hygiene Agency.

2. Algorithm used for calculation of L_{eq} came from NOISESLICE 90.

3. All background noise sources are assumed excluded.

E. HOT REFUELING TABLE, TECHNICAL NOTES

1. L_{eq} data came from NOISESLICE 90.

2. Assumptions

   a. A refueling event takes 15 minutes per helicopter, thus 4 helicopters refueling would take one hour.
   b. Aircraft contribute to sound level while waiting to be refueled and while being refueled. After refueled, aircraft no longer contribute to sound exposure for the refueling event.

APPENDIX D

LIST OF ACRONYMS

CO	-	Commanding Officer
CRAC	-	Community Relations Advisory Council
dB	-	Decibel
DEH	-	Directorate of Engineering and Housing
DNL	-	Day-night levels
HE	-	High explosive
HQ USAREUR	-	Headquarters U.S. Army - Europe
ICUZ	-	U.S. Army's Installation Compatible Use Zone program
L_{eq}	-	Equivalent sound level
Lr	-	Noise rating level
LTA	-	Local training area
LTA-C	-	Local training area coordinator
MILCOM	-	Military community
MTA	-	Major training area
NATO	-	North Atlantic Treaty Organization
NEF	-	Noise exposure forecast
PAO	-	Public affairs officer
REFORGER	-	Return of Forces to Germany
SEL	-	Sound exposure level
SOP	-	Standard operating procedure
TRADOC	-	U.S. Army Training and Doctrine Command

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